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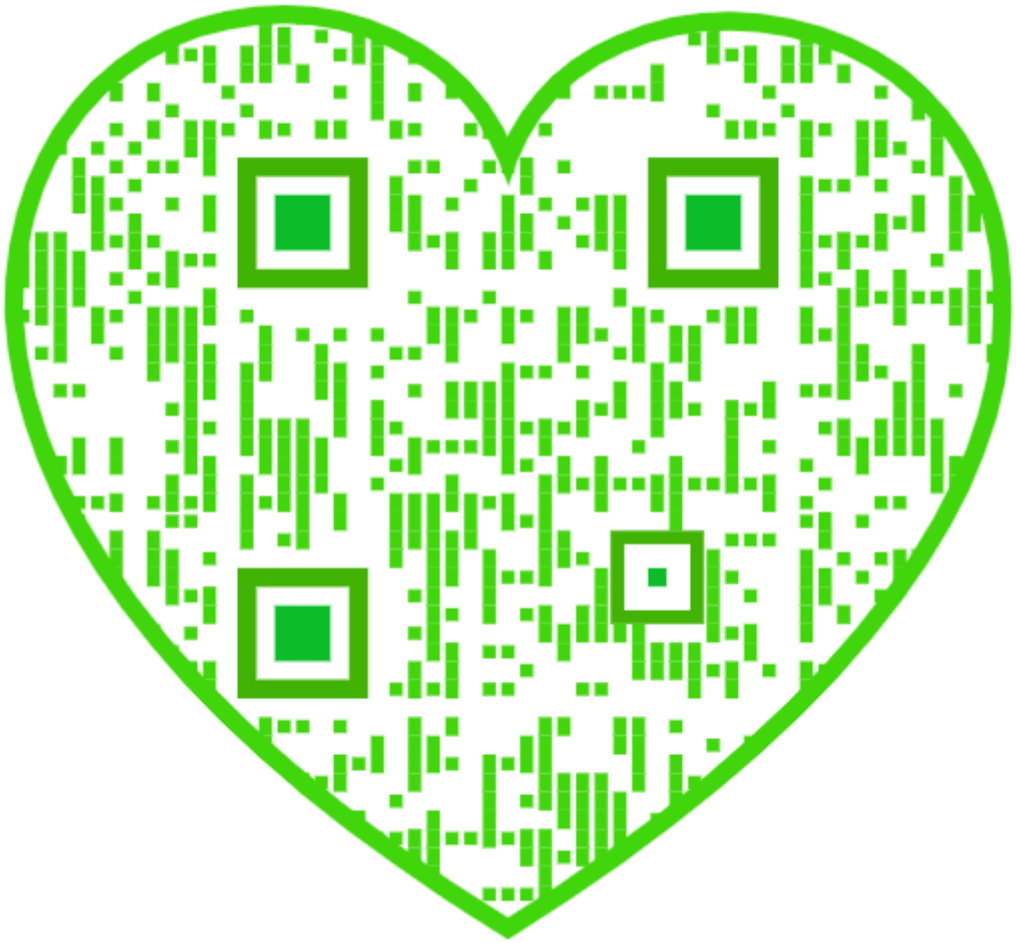

FOUNDRYMAN'S REFERENCE BOOK

A convenient pocket-book of reference for all persons interested in iron or brass foundrys, either as draftsman, pattern makers, foundry foreman, moulders, or coremakers

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BY
JAMES F. BOWE
Practical Moulder and Foundry Manager
PITTSFIELD, MASS.

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PREFACE

All men engaged or interested in foundry work, it matters not in what capacity, often require information which cannot be carried in the mind or remembered at the moment.

To obviate the necessity of looking through several large and more pretentious volumes is the object sought. In preparing the following pages the aim has been to present in a convenient, brief and condensed form, tables, rules, formula and other data which experience has proved to be of value to foundrymen.

THE AUTHOR

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Weights and Measures

TROY

24 grains (gr.).....1 pennyweight—pwt.
20 pwt.....1 ounce—oz.
3.2 grains.....1 carat, diamond wt.

By this weight gold, silver and jewels only are weighed. The ounce and pound in this are the same as in apothecaries' weight.

APOTHECARIES'

20 grains.....1 scruple
3 scruples.....1 drachm
8 drs.....1 ounce
12 ozs.....1 pound

AVOIRDUPOIS

16 drachms.....1 ounce
16 ounces.....1 pound
25 lbs.....1 quarter—qr.
5,760 grains apothecaries' or troy weight.....1 lb.
7,000 grains avoirdupois weight.....1 lb.
4 grs..... 100 weight—cwt.
20 hundred weight.....1 ton

Therefore, 144 lbs. avoirdupois equal 175 lbs. apothecaries' or troy.

LIQUIDS

1 gallon oil weighs 7.32 lbs... avoirdupois
1 gallon distilled water .8.33 lbs.
1 gallon sea water...8.55 lbs.
1 gallon proof spirits 7.68 lbs.

MISCELLANEOUS

Iron, Lead, etc.

14 pounds.....1 stone
21½ stones.....1 pig
8 pigs.....1 fother

Beef, Pork, etc.

200 pounds.....1 barrel
196 lbs. (flour).....1 barrel
100 lbs. (fish).....1 quintal

DRY

2 pints.....1 quart—qt.
8 quarts.....1 peck—pk.
4 pecks.....1 bushel—bu.
36 bushels.....1 chaldron

LIQUID OR WINE

4 gills.....1 pint—pt.
2 pints.....1 quart—qt.
4 quarts.....1 gallon—gal.
31½ gallons...1 barrel—bbl.
21 barrels..1 hogshead—hhd.

U. S. Standard Gallon..... 231 cubic inches
Beer gal.....282 cubic in.
36 beer gallons.....1 bbl.

TIME

60 seconds.....1 minute
60 minutes.....1 hour
24 hours.....1 day
7 days.....1 week
4 weeks.....1 lunar month
28, 29, 30, or 31 days..... 1 calendar month
30 days (in computing interest).....1 month
52 weeks and 1 day or 12 cal. months..... 1 year
365 days, 5 h., 48 min. and 49 seconds.....1 solar year

CIRCULAR

60 seconds.....1 minute
60 minutes.....1 degree
30 degrees.....1 sign
90 degrees.....1 quadrant
4 quadrants or 360 degrees.. 1 circle

Metric Equivalents

LINEAR MEASURE

1 centimeter—0.3937 in.
1 decimeter—3.937 in.—0.328 feet
1 meter—39.37 in.—1.0936 yards
1 dekameter—1.9884 rods
1 kilometer—0.62137 mile
1 in.—2.54 centimeters
1 ft.—3.048 decimeters
1 yard—0.9144 meter
1 rod—0.5029 dekameter
1 mile—1.6093 kilometers

SQUARE MEASURE

1 sq. centimeter—0.1550 sq.in.
1 sq. decimeter—0.1076 sq. ft.
1 sq. meter—1.196 sq. yard
1 are.—3.954 square rods
1 hektar—2.47 acres
1 square kilometer—0.386 sq. in.
1 sq. in.—6.452 sq. centimeters
1 sq. ft.—9.2903 sq. decimeters
1 sq. yard—0.8361 sq. meter
1 square rod—0.2529 are.
1 acre—0.4047 hektar
1 sq. mile—2.59 sq. kilometer

MEASURE OF VOLUME

1 cu. centimeter—0.061 cu. in.
1 cu. decimeter—0.0353 cu. ft.
1 cu. m'r } — { 1.308 cu. yd.
1 ster } — { 0.2759 cd.
1 liter — { 0.908 qt. dry / 1.0567 qt. liq.
1 dekaliter — { 2.6417 gal. / .135 pecks
1 hektoliter—2.8375 bush.
1 cu. inch—16.39 cu. centimeter
1 cu. ft.—28.317 cu. decimeters
1 cu. yd.—0.7646 cu. meter
1 cord—3.624 sters
1 qt. dry—1.101 liters
1 qt. liq.—0.9463 liter.
1 gallon—0.3785 dekaliter
1 peck—0.881 dekiliter
1 bushel—0.3524 hektoliter

WEIGHTS

1 gram—0.03527 ounce
1 kilogram—2.2046 lbs.
1 metric ton—1.1023 English ton
1 ounce—28.35 grams
1 pound—0.4536 kilogram
1 English ton—0.9072 metric ton

Approximate Metric Equivalents

1 decimeter—4 inches
1 meter—1.1 yards
1 kelometer—⅝ of mile
1 hektar—2½ acres
1 ster. or cu. meter—¼ of a cord
1 liter — { 1.06 qt. liquid / 0.9 qt. dry
1 hektoliter—2⅝ bushels
1 kilogram—2 1/5 pounds
1 metric ton—2200 pounds

METRIC SYSTEM

Measures of Weight

(Unit Gramme)

	Grains	Oz. Troy	Lb. Avor.	Cwt.
Centigramme....	0.15432	.....	.....	.....
Decigramme.....	1.54323	0.003	.....	.....
Gramme.....	15.43235	0.032	0.002	.....
Decagramme	154.32349	0.321	0.022	.....
Hectogramme....	1543.23488	3.215	0.220	0.009
Kilogramme.....15432.34880		32.150	2.204	0.011

Measures of Length

(Unit Metre)

	Inches	Feet	Yards	Miles
Millimetre.....	0.03937	0.003	0.001	.....
Centimetre.....	0.39371	0.032	0.010	.....
Decimetre.....	3.93708	0.328	0.109	.....
Metre.....	39.37079	3.280	1.093	.....
Decimetre.....	393.70790	32.808	10.936	0.006
Hectometre.....	3937.07900	328.089	109.363	0.062
Kilometre.....39370.79000		3280.899	1093.633	0.621

Convenient Multiples for Conversion

To Convert		
Grains to Grammes.....	multiply by	.065
Ounces to Grammes.....	" "	28.35
Pounds to Grammes.....	" "	453.6
" " Kilogrammes.....	" "	.45
Cwts. to "	" "	50.8
Tons " "	" "	1016.
Grammes to Grains.....	" "	15.4
" " Ounces.....	" "	0.35
Kilogrammes to Ounces	" "	35.3
" " Pounds	" "	2.2
" " Cwts.	" "	.02
" " Tons	" "	.001
Inches to Millimetres	" "	25.4
" " Centimetres	" "	2.54
Feet to Metres	" "	.3048
Yards to "	" "	.9144
" " Kilometres, ...	" "	.0009
Miles " "	" "	1.6
Millimetres to Inches	" "	.04
Centimetres to "	" "	.4
Metres to Feet	" "	3.3
" " Yards	" "	1.1
Kilometres to Yards	" "	1093.6
" " Miles	" "	.62

1 Yard=0.9144 Metre. 1 Sq. Metre=1.196 Sq. Yard.
1 Litre=1.760 Pintsor 0.22 Gals.

FRACTIONAL PART OF AN INCH
(Expressed in Decimals.)

1–8 = .12500	1–64 = .015625
1–4 = .25000	3–64 = .046875
3–8 = .37500	5–64 = .078125
1–2 = .50000	7–64 = .109375
5–8 = .62500	9–64 = .140625
3–4 = .75000	11–64 = .171875
7–8 = .87500	13–64 = .203125
1–16 = .06250	15–64 = .234375
3–16 = .18750	17–64 = .265625
5–16 = .31250	19–64 = .296875
7–16 = .43750	21–64 = .328125
9–16 = .56250	23–64 = .359375
11–16 = .68750	25–64 = .390625
13–16 = .81250	27–64 = .421875
15–16 = .93750	29–64 = .453125
1–32 = .03125	31–64 = .484375
3–32 = .09375	33–64 = .515625
5–32 = .15625	35–64 = .546875
7–32 = .21875	37–64 = .578125
9–32 = .28125	39–64 = .609375
11–32 = .34375	41–64 = .640625
13–32 = .40625	43–64 = .671875
15–32 = .46875	45–64 = .703125
17–32 = .53125	47–64 = .734375
19–32 = .59375	49–64 = .765625
21–32 = .65625	51–64 = .796875
23–32 = .71875	53–64 = .828125
25–32 = .78125	55–64 = .859375
27–32 = .84375	57–64 = .890625
29–32 = .90625	59–64 = .921875
31–32 = .96875	61–64 = .953125
	63–64 = .984375

Degrees of Heat Used in Metallurgy

6400 deg. F.	Electric furnace
6300 " "	Oxy. Acetylene torch
5400 " "	Thermit welding
5100 " "	Oxy-hydrogen blow pipe
4700 " "	Lime melts
4600 " "	
4200 " "	Iridium melts
4000 " "	Cromite and Boron melts
3900 " "	Magnesia Brick melts
3800 " "	Alundum and Alumina melts
3600 " "	Tungsten melts
3500 " "	Blast furnace at tuyeres
3200 " "	Platinum and vanadium melts
3100 " "	Silica Brick melts
3000 " "	Bessemer Converter and fire brick
2800 " "	Open hearth Steel
2700 " "	Pig Iron Blast furnace
2600 " "	Iron is Brilliant white
2500 " "	" is bright white
2400 " "	" is white Pouring heat for grey cast iron
2300 " "	" clear orange
2200 " "	" bright orange, cast iron melts
2100 " "	" dull orange, copper melts
2000 " "	" deep orange, red metal melts
1800 " "	" clear red, yellow brass melts
1600 " "	" full red
1400 " "	" cherry red
1300 " "	" dull red Pouring temperature Aluminum
1000 " "	" red just visible

400 to 600 core oven heat

Diameter and Safe Working Load in Pounds of Wire Ropes, Chains and Manilla Ropes of Good Quality

When used double or other multiples increase load proportionally.

Safety First

Wire Rope		Chain	Fibre Ropes
Diam.	Work. Load	Work. Load	Work. Load
3/8	1500	1200	120
1/2	2400	2400	250
5/8	4000	4000	360
3/4	6000	5500	520
7/8	8000	7500	620
1	10000	9500	750
1 1/8	13000	12000	1000
1 1/4	16000	15000	1200
1 3/8	19000	22000	1400
1 1/2	22000	30000	1600
1 3/4	27000	40000	2100
2	33000	50000	2800

Weight of 1 Cubic Foot of Materials Used in Foundry

	Lbs. per cubic ft.	Wt. lbs. per bush.
Ashes	37	
Brass trimmings	157	
Charcoal not crushed	18	20
Coke	32	40
Coal, Anthracite	60	86
Coal, Bituminous	53	80
Cast Iron turnings	140	
Core compound (Tar)	35	
Fire Clay	90	
Flour	36	
Fire Brick	102	
Loam gravel	103	
Limestone	90	
Moulding sand	88	
Plumbago	40	
River sand	90	
Sea coal	53	
Soap stone	62	
White sand	84	

Pig iron as usually piled will average 7½ cubic feet per ton.

When piled very closely 7 cubic ft. to ton.

Loosely piled 8 cubic ft. to ton.

Cubic ft.: 1728 cubic inches.

One Bushel: 2150 cubic inches.

Equivalent of Tons in Pounds, 2240 Pounds to Ton

Ton	Pounds	Ton	Pounds	Ton	Pounds
17	38080	25	56000	33	73920
17¼	38640	25¼	56560	33¼	74480
17½	39200	25½	57120	33½	75040
17¾	39760	25¾	57680	33¾	75600
18	40320	26	58240	34	76160
18¼	40880	26¼	58800	34¼	76720
18½	41440	26½	59360	34½	77280
18¾	42000	26¾	59920	34¾	77840
19	42560	27	60480	35	78400
19¼	43120	27¼	61040	35¼	78960
19½	43680	27½	61600	35½	79520
19¾	44240	27¾	62160	35¾	80080
20	44800	28	62720	36	80640
20¼	45360	28¼	63280	36¼	81200
20½	45920	28½	63840	36½	81760
20¾	46480	28¾	64400	36¾	82320
21	47040	29	64960	37	82880
21¼	47600	29¼	65520	37¼	83440
21½	48160	29½	66080	37½	84000
21¾	48720	29¾	66640	37¾	84560
22	49280	30	67200	38	85120
22¼	49840	30¼	67760	38¼	85680
22½	50400	30½	68320	38½	86240
22¾	50960	30¾	68880	38¾	86800
23	41520	31	69440	39	87360
23¼	52080	31¼	70000	39¼	87920
23½	52640	31½	70560	39½	88480
23¾	53200	31¾	71120	39¾	89040
24	53760	32	71680	40	89600
24¼	54320	32¼	72240	40¼	90160
24½	54880	32½	72800	40½	90720
24¾	55440	32¾	73360	40¾	91280

Relative Value of Net Ton of 2000 pounds and Gross Ton of 2240 pounds

Net Ton	Gross Ton	Gross Ton	Net Ton
$10.00 —	$11.20	$10.00 —	$8.929
11.00 —	12.32	11.00 —	9.821
12.00 —	13.44	12.00 —	10.714
13.00 —	14.56	13.00 —	11.607
14.00 —	15.68	14.00 —	12.50
15.00 —	16.80	15.00 —	13.392
16.00 —	17.92	16.00 —	14.286
17.00 —	19.04	17.00 —	15.179
18.00 —	20.16	18.00 —	16.072
19.00 —	21.28	19.00 —	16.966
20.00 —	22.40	20.00 —	17.858

Usual Thickness of Chills for Chilled Work

Diam. of Roll Inches	Thickness of Chill inches	Diam. of Roll Inches	Thickness of Chill inches	Diam. of Roll inches	Thickness of Chill inches
3″	2½″	13	5″	23	8½″
4	2½	14	5¼	24	9
5	3	15	5½	25	9½
6	3	16	6	26	9¾
7	3¼	17	6½	27	10
8	3¼	18	6½	28	10½
9	3¾	19	7	29	10½
10	3¾	20	7½	30	11
11	4¼	21	7½		
12	4½	22	8		

R. R. car wheels chills run from 4 to 5″ thick and give from ½ to ¾″ chill.

Chill is increased by sulphur manganese and crominum also by pouring hot.

Pressure Per Sq. Inch in Moulds Below Cope Joint

Depth Inches	Pressure Per. Sq. in.	Depth Inches	Pressure Per Sq. in.	Depth Inches	Pressure Per Sq. in.
1	.26	19	4.94	37	9.62
2	.52	20	5.20	38	9.88
3	.78	21	5.46	39	10.14
4	1.04	22	5.72	40	10.40
5	1.30	23	5.98	41	10.66
6	1.56	24	6.24	42	10.92
7	1.82	25	6.50	43	11.18
8	2.08	26	6.76	44	11.44
9	2.34	27	7.02	45	11.70
10	2.60	28	7.28	46	11.96
11	2.86	29	7.50	47	12.22
12	3.12	30	7.80	48	12.48
13	3.38	31	8.06	5 ft.	15.60
14	3.64	32	8.32	6 ft.	18.72
15	3.90	33	8.58	7 ft.	21.84
16	4.16	34	8.84	8 ft.	24.96
17	4.42	35	9.10	9 ft.	28.08
18	4.68	36	9.36	10 ft.	31.20

For each additional inch of depth add .26 and multiply this by the number of sq. inches upon which pressure is exerted.

To find the weight required to resist the upward pressure on copes multiply the area in inches of surface acted against by the depth of cope plus the height of pouring heads and then divide by 4 or multiply by .26.

How To Change One Thermometer Reading Into Another

1 degree F = 5556 C.
1 degree C = 1.8 F.

Boiling point of water Reaumur 80, Centigrade 100, Fahrenheit 212. Fahrenheit to Centigrade. Subtract 32 from Fahrenheit reading and multiply the remainder by 5/9ths. To Reaumur subtract 32 and multiply by 4/9ths. To change Centigrade to Fahrenheit multiply Centigrade by 9/5ths and add 32. To change Centigrade to Reaumur multiply Centigrade by 4/5ths. To change Reaumur to Fahrenheit multiply Reaumur reading by 9/4ths and add 32 degrees.

Ladles. Their Dimensions Lined Up and Capacity in Pounds of Molten Cast Iron

Diam	Depth	Capacity per inch	Total Capacity
5 inches	6 inches	5.1 lbs.	30.6 lbs.
6	7	7.3 "	51.1 "
7	8	9.5 "	76. "
8	9	13. "	117. "
9	10	16.5 "	165. "
10	11	20.4 "	224. "
11	12	25. "	300. "
13	13	35. "	455. "
17	18	59. "	1062. "
20	20	82. "	1640. "
22	22	99. "	2178. "
24	25	118. "	2950. "
27	28	149. "	4172. "
31	32	197. "	6304. "
34	35	237. "	8295. "
39	40	311. "	12440. "
43	44	379. "	16676. "
46	48	434. "	20832. "
49	50	491. "	24550. "
52	53	553. "	29309. "
54	56	597. "	33432. "
60	62	737. "	45694. "
66	68	892. "	60656. "
72	74	1061. "	78514. "

Capacity of Boxes

Pint Box,	3× 3× 3½ inches
Quart "	4× 4× 4 1/5 inches
Half Gallon,	7× 7× 2¾ inches
Gallon,	8× 8× 4⅛ inches
Peck,	8× 8× 8 2/5 inches
Half Bushel,	10×10×10¾ inches
Bushel,	18×15½×8 inches

Help in Care of Burns, Fainting, Etc. For Burns

Use a two per cent solution of picric acid or cover with cooking soda and lay wet cloth over it, or apply a mixture of linseed oil and lime water. Whites of eggs and olive oil or linseed oil plain or mixed with chalk or whitening may be applied.

Fainting

Loosen clothing, place flat on back with head lower than rest of body, allow plenty of fresh air, sprinkle with water, chafe hands, give patient twenty drops of spirit of ammonia in half glass of water. Strong coffee or wine glass of whiskey will help revive. Do not try to pour liquid down throat of unconscious person. It may cause death from choking. If partially overcome by gas get into the fresh air and take twenty drops of ammonia in glass of water at short intervals.

Table giving Sp. Gr., Sp. Heat, Tensile Strength, Heat and Electrical Conductivity, Melting Point and Wt. per cu. in. of Metals

	Specific Gravity	Tentile Strength	Specific Heat	Heat Conductivity	Electrical Conductivity	Melting Point	Weight per Cubic Inch
Aluminum	2.6	20000	.225	31.33	54.20	1214	.096
Antimony	6.7	...	.050	4.03	2.05	1166	.244
Arsenic	5.72	...	.083	...	2.67	1562	...
Bismuth	9.82	...	.030	1.8	.87	510	.244
Cadmium	8.65	...	.055	20.06	13.46	612	.312
Calcium	1.58	...	.168	25.4	12.5	1490	.057
Chromium	5.	...	.099	...	...	2750	.1804
Cobalt	8.55	...	.107	17.2	9.68	2782	.308
Copper	8.85	36000	.093	73.6	54.	1949	.3195
Gold	19.3	20000	.0316	53.2	43.84	1947	.6949
Iridium	22.38	...	.0323	...	...	3960	.8076
Iron Cast	7.48	25000	.112	11.9	9.68	2350	.2604
Lead	11.35	3000	.032	8.5	4.8	620	.41
Magnesium	1.75	...	.245	34.3	22.84	1200	.064
Manganese	8.	...	.122	...	...	2273	.288
Mercury	13.60	...	.032	5.3	1.	—39	.49
Nickel	8.6	...	.108	...	7.37	2646	.317
Platinum	21.5	...	.032	37.9	8.042	3236	.775
Potassium	.865	...	.166	45.	...	144	.031
Silver	10.53	40000	.057	100.	63.84	1751	.379
Sodium	.97	...	.2734	36.5	18.3	208	.035
Tin	7.35	4600	.056	15.2	12.4	450	.265
Titanium	5.3	...	.1135	...	...	3270	.1913
Tungston	17.3	...	...	...	...	5430	.6243
Vanadium	5.5	...	...	...	...	3146	.1987
Zinc	7.	7500	.096	36.	29.	786	.2526
Boron	...	...	...	...	...	4262	...
Phosphorus	...	...	...	...	...	111	...
Sulphur	...	...	...	...	...	241	...
Silicon	...	...	...	...	...	2588	...
Carbon	...	...	...	...	over	6500	...

Aluminum: Al., At. Wt. 27.1, Sp. Gr. 2.6

A silvery white metal, weighs 1/3 as much as cast iron and 5 times as much as white pine, tenacity being 1/3 that of wrought iron. Hydrochloric Acid dissolves it with ease. Nitric and sulphuric do not act upon it at ordinary temperatures. Small percentages are used to deoxodize steel. .1% added to cast iron in the ladle increases the fluidity, decreases the combined and increases the graphitic carbon. In the brass foundry 1 to 8 ounces may be added to 100 lbs. of molten brass to decrease the zinc fumes and cause the metal to run up sharp. Various percentages are used in the production of die castings, manganese and aluminum bronzes. Zinc when melted for castings is improved in casting quality by the addition of .1% . Aluminum castings in general use contain percentages of zinc or copper, often both.

It can be melted in either plumbago or cast iron pots and fluxed with salammoniac or chloride of zinc. The sand used for moulding should be fine, free from mica, worked quite dry and not rammed too hard. Use chills and risers to prevent shrinkage. Pour at a low heat.

Antimony: Sb., At. Wt. 120., sp. gr. 6.7

Bluish white metal, very crystalline and easily pulverized. Because of its property of expanding when it solidifies it is used largely in mixtures for patterns, type and Brittania ware, also in antifriction bearing metals and antimonial lead because of its hardening property. It melts at 1166 F. and burns in open air with a bluish white flame. Cubical expansion from 32 to 212 F. is .007.

Arsenic: As., At. Wt. 75., Sp. gr. 5.7

Bright steel grey color. Volatilized at 356 F. When heated gives off an odor of garlic. It is used as a hardening element in Copper and Lead.

Bearing Bronze, Copper 80, Tin 9, Lead 10, Arsenic 1, Arsenic Lead 2% Arsenic.

Bismuth: Bi., At. Wt. 208.5, Sp. gr. 9.82

Hard, brittle and distinctly crystaline reddish-white metal with a metallic lustre. It looks like Antimony but is distinguished from it by its reddish tint. Bismuth pulverizes readily, melts at about 510 F. Its tensile strength is 6400 lbs per sq. inch. Cubical expansion from 32 to 212 F. is .0040. As it imparts the properties of low fusing points and expansibility it is used in making safety-plugs for boilers, fuseable alloys stereotype, pattern metals etc. A small percentage will harden and toughen lead. As alloys of Bismuth, tin and Lead take very fine impressions they are often used for moulds and medals.

Boron: B., At. Wt. 11.

Boron Suboxide is used as a flux in the production of copper castings where high electrical conductivity is required.

Cadmium: Cd., At. Wt. 112.4, Sp. gr. 8.65

A white metal closely resembling Tin and of about the same hardness. Like Tin it gives a creaking sound when bent. It melts at about 500 F. It is malleable and ductile, cubical expansion from 32 to 212 F. .0094. It is used in some fuseable alloys with Lead, Tin and Bismuth.

Carbon: C.

This element is more widely distributed than any other except Oxygen. Its melting point is above 6500 F. Graphite, Lampblack, Charcoal, Coal, Coke and Diamonds are composed very largely of Carbon. Regular foundry grades of cast Iron usually contain from three to four percent. The fluidity and life is largely determined by the amount and the ratio which exists between its two forms, graphitic and combined. Silicon decreases the total carbon and changes it from the combined to the graphitic state. Total Carbon may be increased by the use of Manganese. It also has a quality imparted to it by the kind of fuel with which the iron ore is smelted. This accounts in part for the difference between charcoal and coke iron.

Copper: Cu., At. wt. 63.6

Reddish colored metal, very tenacious, malleable, and ductile. With the exception of Silver it is the best known conductor of electricity. Its tenacity is next to Iron. Tensile strength from 20,000 to 30,000 lbs. per sq. inch. Its melting point is about 1950 F. It is used as a base in Bronze and Brass mixtures. Cubical expansion from 32 to 212 F. .0051. Nitric Acid dissolves it, Sulphuric Acid when heated with the metal will attack it, Hydrochloric Acid does not act upon it. There are many grades and brands of Copper. Lake and Electrolytic being considered the best for casting purposes.

Iron: Fe., At. Wt. 56., Sp. gr. 7.43

Pure Iron is almost unknown. Its melting point is given as 3000 F. The grades used in foundries usually have from 6 to 8% of metaloids and melt at 2360 F. The various grades of foundry Irons are determined by the percentages of the metaloids, carbon, silicon, sulphur, manganese and phosphorus which they contain. See table analysis of cast iron.

Lead: Pb., At. Wt. 206.9, Sp. gr. 11.38

Melts at about 625 F. It is a heavy soft malleable dark grey metal of a brilliant lustre when first cut. Its tensile strength is about 1800 lbs. per sq. inch. Its weight per cubic foot 710 lbs. It is used extensively for sulphuric acid chambers and evaporating pans, also as an alloy in many serviceable metals. In the brass foundry it is often used in mixtures to lower the cost of the metal. From 1 to 3% is frequently used in red metal castings which are to be rapidly finished on machine tools. From 5 to 10% is generally introduced into Acid Bronze and from 5 to 30% in Bearing Bronze. As an alloy it is used in the composition of pattern, type and white metals, also fusible alloys and soft solders, cheap babbits and box linings. It should not be used in mixtures containing Aluminum or Silicon.

Magnesium: Mg., At. Wt. 24.36, Sp. gr. 1.75

Silvery white metal with a high lustre, very malleable and ductile. It is used in taking flash-light pictures, in making fire-works and as an alloy in some Aluminum mixtures. It is one of the lightest of metals. It melts at about 1200 F. Cubical expansion of .0083 from 32 to 212 F.

Manganese: Mn., At. Wt. 55., Sp. gr. 8.

White-grey metal, melting at about 2280 F. Used as an alloy in cast Iron, steel and Manganese bronze. Its tendency is to reduce sulphur, increase density and combined carbon. It also raises the saturation point of total carbon. Light soft castings should have about .60%. Medium weight castings .70%. Heavy 1.00% chilled work 2.00%. Semi Steel from .75 to 1.25 Manganese Bronze .1. Small percentages of Manganese Copper are often used to deoxidize brass mixtures.

Mercury: Hg., At. Wt. 200.3, Sp. gr. 13.60

The only metal that is liquid at ordinary temperatures becoming solid at 39 F. below zero. It is silvery white with a high lustre.

Nickel: Ni., At. Wt. 58.7, Sp. gr. 8.6

A hard yet ductile metal with tenacity about the same as Iron. Its melting point is high, being about 2600 F. It is used as an alloy in making nickel-steel and for nickel plating, also with copper to produce German-Silver. Cubical expansion from 32 to 212 F. .0037. Mixtures of Copper and Lead for bearings contain small amounts to prevent lead sweat.

Phosphorus: P.

A pale amber colored metal, waxy in appearance. It ignites readily under ordinary temperatures and must be kept under water. It can be cut like wax, melts at 112 F. boils at 290 F. When heated to 240 F. out of contact with the air it changes to red or amorphous Phosphorus. This is not so poisonous nor does it ignite as readily as the other. It

adds fluidity and hot-shortness to Phospor Bronze. To Iron it adds fluidity and cold-shortness. Because it possesses a great affinity for oxygen it is often used in brass foundries as a deoxidizer to remove the surplus oxygen which the metal may contain or has absorbed while being melted. It is usually introduced in the shape of Phosphor Tin or Phosphor Copper. 1% of Phosphorus is generally sufficient to remove the oxygen from copper alloys. Cast Iron for ordinary work usually contains about .60%.

Silicon: Si., At. Wt. 28.4

When obtained in the form of crystals, Silicon is of a grey color and harder than glass. It is one of the most widely distributed of the non-metalic elements. At a very high temperature it combines with Iron and other metal. Its melting point is about 3600 F. No. 1 Foundry Iron usually contains 3%. It has the property of adding fluidity to Iron and of changing the carbon from the combined to the graphitic state. It is also used in the Brass Foundry as a flux and deoxidizer. It burns out the oxids, gives to the castings an even smooth grain and increases the strength very perceptably. Do not use in mixtures containing Lead. It is generally introduced into the molten metal in the form of Silicon Copper which contains from 15% to 20% Silicon, about 1% of the latter being sufficient.

Sulphur: S.

A yellow brittle substance which melts at 114 F. It makes Iron hard, white, red-short and sluggish. It also gives rise to blow-holes during solidification.

It is removed to a limited extent by silicon, lime, flour spar and Manganese. It should never exceed .07% in Iron, or .8 in coke when making the usual grade of machinery castings. Chilled rolls and car wheels often contain .1% as it increases the combined carbon, closes the grain and promotes chill. 1% is used in mixtures of copper containing high percentages of lead to prevent lead sweat.

Tin: Sn.

Lustrous and white in color, tenacity about 3400 lbs. per sq. inch. It melts at 450 F, is soft and malleable, a bar of it giving forth a creaking sound when bent. It is used as an alloy in Bronze, Aluminum and composition castings, also as a base in many well known bearing, pattern, and die cast metal mixtures. Britanna metal and fusible alloys contain large percentages. Safety plugs for boilers are usually filled with pure tin. Billiton and Banca are two of the best known brands.

Zinc: Zr.

A bluish white metal, highly crystaline. Melts at about 788 F. and weighs 436 lbs. per cubic foot. Tenacity 6000 lbs. per sq. inch. Electric conductivity 29. Cubical expansion between 32 and 212 F. .0088. Specific heat .096. Heat conductivity 36.

As an alloy it is used extensively in the production of brass, bronze, German silver, die and aluminum castings. When used alone for castings flux with sal ammoniac and add .01% of Aluminum. Bertha and Horse Head are the trade names of the two best brands.

Sands Analysis of Foundry

	Silica	Alumina	Iron	Lime	Magnesia	Organic Matter	Combined Water
Fire Sand	98	1.40	.10	.20	.15	—	.15
Silica Sand	95	1.50	.30	1.50	.50	.20	1.
Coarse Molding Sand	88	7.	2.	.75	.75	.5	1.
Medium Molding Sand	87	9.	2.15	.50	.85	.5	..
Stove plate Bench & Brass Sand	83	9.5	4.5	.70	1.	.5	.8
French Moulding Sand	..	..	..	..	..	..	..

Green Sand Facing for Various Thickness of Casting

Thickness	New Moulding	Heap Sand	Sea Coal
1/4″ to 3/8″	6 parts	8 parts	1 part
3/8″ to 1/2″	5 parts	6 parts	1 part
1/2″ to 3/4″	4 parts	5 parts	1 part
3/4″ to 1″	4 parts	4 parts	1 part
1″ to 1 1/2″	4 parts	3 parts	1 part
1 1/2″ to 4″	4 parts	2 1/2 parts	1 part

To make the facing more open mix with it coarse sharp sand.

For Skin dry work temper with beer or molasses water and mix with the facing 1 part flour to 15 or 20 parts sand.

Facing sand should be thoroughly mixed and carefully tempered.

Coke and Coal, Analysis of For Melting Iron

	Fixed Carbon	Sulphur	Ash	Volatile Matter
Coke.....	88	.85	10.	1.25
	to	to	to	to
	90	.70	7.88	.75
Coal, Anthracite...	84	.75	8.	4.38

One pound of good coke will produce in blast furnace about 1 pound of pig iron.

In cupola 8 pounds of molten metal.

In Brass pit furnace 2 lbs. molten metal.

In Brass pit furnace 2 1/2 lbs. with good hard coal.

Tilting coke furnace with blast 1 lb. coke to 4 1/2 lbs. melted metal.

Crucible oil furnace 3 gal. oil per 100 lbs. of melted metal.

Open flame oil furnace 2 gal. oil per 100 lbs. of melted metal.

Not many iron foundrys produce more than 4 1/2 lbs. of castings per lb. of coke purchased.

Approximate Analysis of Iron Used in Making Castings

	Sil.	Sul.	Phos.	Mang.	C. C.	G. C.	Shrinkage	Transverse
							bar 1 12″	×1×
No. 1 Foundry	3.00	.02	.75	.40	.15	3.40	.11	2200
" 2 "	2.50	.04	.70	.40	.30	3.25	.12	2300
" 3 "	1.75	.05	.70	.55	.40	3.00	.13	2500
					T. C.			
Spiegeleisen.....	.75	nil.	.10	.20	5.		..	..
Fero Phosphorus ..	.25	"	20.	.15	.15		..	..
Malleable, Common	1.00	.05	.15	.50	3.75		..	..
Bressemer, Straight	1.25	.04	.10	.60	..		..	..
Grey Forge.....	1.00	.09	.65	.50	3.80		..	..
Basic.....	.75	.05	.40	.75	..		..	..
					C.C.	C.G.		
CharcoalNo. 1.....	2.60	.021	.35	.45	.22	3.55	.125	2400
" " 2.....	2.40	.031	.35	.44	.22	3.50	.125	2600
" " 3.....	1.50	.035	.35	.35	.34	3.30	.13	2900
" " 4.....	.75	.04	.35	.24	.63	2.90	.14	3300
" " 5.....	.37	.042	.35	.13	2.10	1.19	..	..
Fero Silicon.....	11.00	.04	.80	.60	T.C	3.	..	..
Fero Manganese ..	2.5	.04	.70	80.	"	6.	..	..
					C.C.	G.C.		
Machinery Scrap, heavy.....	1.75	.08	.70	.50	.30	3.25	..	..
Machinery Scrap, Light.....	2.25	.08	.80	.50	.20	3.40	..	..
Car Wheel Scrap ..	.60	.14	.40	.60	.75	3.25	..	..
Stove Plate Scrap..	2.75	.09	.85	.45	.15	2.75	..	..
Steel Scrap	.03	.04	.10	.5	T.C.	.60	—	..

Table showing the interaction of the metaloids on each other and cast iron.

	Fluidity	Softness	Shrinkage	Strength	Density	Chill	Sulphur	C. Carbon	G. Carbon
Silicon	Increases	Increases	Decreases	Decreases	Decreases	Decreases	Decreases	Decreases	Increases
G. Carbon	Increases	Increases	Decreases	Decreases	Decreases	Decreases	Decreases	Decreases	.....
C. Carbon.....	Decreases	Decreases	Increases	Increases	Increases	Increases	Neutral	.....	.....
Manganese	Decreases	Decreases	Increases	Increases	Increases	Increases	Decreaess	Increases	Decreases
Phosphorous.....	Increases	Neutral	Neutral	Decreases	Promotes	Decreases	Neutral	Neutral	Neutral
Sulphur	Decreases	Decreases	Increases	Decreases	Increases	Promotes	.....	Increases	Decreases

To Figure Iron Mixture for Cupola

Prepare the following form and fill it out with the analysis of the irons to be used in the mixture. Multiply the percentage of the element in the irons by the percentage it is proposed to use in 100 lbs. Should it not total up as wanted change the percentage to be used until the right result is obtained. After having found the percentage of each iron necessary to produce the required analysis in 100 lbs. multiply the amount of charge by these percentages.

By using ferro irons and steel any desired analysis may be produced.

The following form will help to explain

Analysis of Iron Used

% used in charge	Kind of Iron used	Amount in charge	Silicon		Sulphur		Phosphorus		Manganese	
			in Iron	in Cge.	in Iron	in Cge.	in Iron	in Chg.	in Iron	in Chg.
40	No. 2.....	1600	2.50	1.000	.04	.016	.70	.28	.40	.16
10	No. 3.....	400	1.75	.175	.05	.005	.70	.07	.55	.055
10	Remelt ...	400	2.25	.225	.06	.006	.70	.07	.50	.050
30	Scrap.....	1200	2.25	.675	.08	.024	.80	.24	.50	.150
10	Ferro Sil. .	400	11.00	1.100	.04	.004	.80	.08	.60	.060
100%		4000	#	2.175		.055		.74		.475

Analysis of Iron Mixture as Charged

The usual loss of silicon in melting is .25, of manganese .10, and the gain in sulphur is approximately .03.

Analysis of Iron Mixtures Used by Foundrys Specializing in the Following Classes of Work

	Sil.	Sul.	Phos.	Mang.	Total Carbon
Acid	1.50	.05	.50	1.25	3.25
Agricultural	2.25	.06	.60	.70	3.40
Air Cyl.	1.65	.09	.40	.80	3.25
Ammonia	1.70	.09	.40	.70 to .90	3·30
Annealing Pots	1.50	.06	.20	.60 to 1.	3.00
Auto Parts	2.00	.09	.45	.60 to .80	3.25
Auto Cyl.	1.85	.09	.45	.60 to .80	C. C. .60 G. C. 3.15
R. R. Work	2.00	.08	.50	70	3.50
Brake Shoes	1.50	.10	.30	.50 to .70	3.25
Car Wheel	.60	.11	.30	60	C. C. .75 G. C. 3.50
Chilled Castings	1.00	.09	.40	1.00	C. C. 3.00 G. C. 2.75
Chills	2.00	.07	.30	.80	C. C. .50 T. C. 3.25
Crusher Jaws	1.00	.09	.30	.90	3.20
Dies Hammer	1.40	.07	.20	.70	3.25
Electrical Work	2.50	.08	.60	.40	3.25
Fire Pots	2.25	.06	.20	.75	3.00
Fly Wheel	1.75	.08	.50	.65	3.25
Friction Clutches	2.00	.09	.30	.60	3.25
Furnace	2.25	.06	.20	.75	3.25
Gas Engine Cyl.	1.50	.08	.40	.80	3.25
Gears, heavy	1.25	.09	.40	.90	3.25
Gears, medium	1.50	.09	.50	.80	3.50
Gears, light	2.00	.09	.60	.70	3.50
Grate Bars	2.25	.06	.20	.75	3.50
Gun Carriage	1.10	.06	.25	.90	C. C. .75 G. C. 2.75
Gun	1.00	.06	.20	1.00	C. C. .80 C. C. .40
Ingot Moulds	1.40	.06	.20	.75	G. C. 3.00
Locomotive Cyl.	1.25	.09	.40	.90	C. C. .50 G. C. 3.00

	Sil.	Sul.	Phos.	Mang.	Total Carbon
					Low
Machinery, heavy	1.25	.10	.40	.90	C. C. .60
Machinery, medium	1.75	.09	.50	.75	3.00
Machinery, light	2.50	.06	.75	.30	3.80
Permanent Moulds	2.25	.07	.30	.75	3.75
Permanent Mould Castings	2.50	.06	.40	.25	3.75
Piano Plate	2.25	.09	.50	.60	3.50
Pipe Water	2.00	.09	.50	.75	3.75
Pipe Fittings	2.25	.08	.60	.75	3.75
Plow Points	1.00	.08	.30	1.00	3.50
Piston Rings	1.75	.08	.40	.50	3.50
Propeller Wheels	1.50	.09	.35	.75	3.50
Pulleys, heavy	2.00	.09	.60	.75	3.50
Pulleys, light	2.50	.08	.60	.50	3.75
Radiator	2.25	.08	.75	.60	3.50
Rolls, Chilled	.75	.08	.30	1.2	3.25
Scales	2.25	.08	.75	.50	3.75
Steam Cyl., heavy	1.25	.09	.30	.90	3.40
Steam Cyl., medium	1.50	.09	.40	.70	3.50
Stove Plate	2.75	.08	.75	.75	3.75
Transformer Tank, medium Size	2.70	.08	.80	.60	3.50
Valves, large	1.50	.09	.30	.70	3.25
Valves, medium	2.25	.07	.50	.60	3.50

Strength in light castings depends upon the amount of combined carbon in casting and varies with it.

The total carbon should be high in order to get plenty of combined carbon without hardness. Silicon rather low to enable combined carbon to form.

Phosphorous enough to cause the metal to run well.

Manganese high to get clean close grain and increase absorption of carbon. Castings should be left in sand until cold.

Semi Steel

To cupola charge of pig and machinery scrap add from five to forty per cent of clean soft steel horse shoes, rail ends, steel castings, boiler plate clippings, etc.

Use enough ferro manganese to give from 2 to 3% in mixture as charged depending on percent of steel used.

Add 10% of coke to amount used for regular grey iron.

Analysis of Mixtures as Charged and Used Successfully

	Steel	Sil.	Sul.	Phos.	Mang.	Test Bar 1×1×12 in.
Auto Cyl.....	20%	2.%	.05	.60	1.	2550 lbs.
Gas Engine ...	25%	1.75	.06	.60	1.25	2700 lbs.
Corlis Cyl's....	30%	1.60	.06	.55	2.50	3000 lbs.
Heavy Frames	35%	1.25	.07	.50	3.00	3600 lbs.

Diameter of Cupola Newly Lined

Table giving capacity and other data of different sizes of cupolas	24″	30″	36″	42″	48″	54″	60″	72″	84
Thickness of sand bottom in inches	3″	3½″	3½″	4″	4″	5″	5½″	6″	6″
Depth from under side of tuyeres to sand bottom	10″	12″	14″	14″	14″	14″	14″	14″	14″
Number of tuyeres	6	6	8	8	10	12	12	14	14
Size of tuyeres	5x3½	8x3½	8x4″	9x4″	10x4½	11x4½	12x5″	12x5	14x5
Diameter of blast pipe	7″	12″	13	15	16	18	20	24	28
Cubic feet of air per minute	800	1500	2000	3000	4000	5000	6500	9000	12500
Blast pressure oz	8½	10	11	12	13	14	16	16	16
Coke used on first charge	250	450	550	900	1400	1700	2100	2500	3000
Iron used on first charge	700	1200	1500	2700	4000	5000	6000	7000	9000
Coke used on following charges	50	75	100	150	200	200	400	500	700
Iron used on following charges	500	700	1000	1500	200	3000	4000	5000	7000
Iron melted per hour	3000	6000	8000	12000	16000	20000	26000	38000	50000

Cupola should melt about 10 lbs. per hour per square inch of cupola area.

It requires about 300 lbs. of coke per ton iron and 30000 cubic feet of air per ton iron.

¾″ diam. tap hole will when running continuously deliver five ton of iron per hour.

⅞ inch ten ton of iron per hour.

1 inch fifteen ton of iron per hour.

1⅛ inch is usual on cupolas not running continuously.

Iron should run from spout in from 7 to 10 minutes after blast starts.

Pig Iron loss in melting is about 4½%.

Machinery scrap 5 to 7%.

Clean stove plate 8%.

Old and rusty stove plate 10 to 12%.

Put sand bottom in with slight pitch to rear of cupola. This will lessen the pressure in tap hole and cause the iron to run quietly. Iron will not remain on the bottom as the blast will syphon it out.

Dry Sand Facing Mixtures Oven Dried

Number	Millville Gravel	Jersey Moulding	Fire Sand	Coarse Moulding	Med. Moulding	Coarse Bank	Used Heap Sand	Fire Clay	Flour	Sea Coal	Saw Dust	Thin Clay Wash	Molasses Water
												Temper with	
1			1½	1	1	2 1/5			⅓	½	1/7	"	
2			4	4		1			½	½		"	
3		1	1	1					1/5	1/5		"	
4	10				5		5		Tar Com. 1 Flour 1			"	
5			10	5			.15	1	1	1		"	
6					6	12			1	1		"	
7	15						15	1	½			"	"

Nos. 1-2-3-4 for heavy work, large cylinders, engine beds, anvil blocks, balance wheels, etc.

Nos. 5 and 6 not so strong for medium heavy work.

No. 7 for thin light castings.

Skin Dry Facing Mixtures

No. 1. Skin dry facing 1″ thick on pattern. New coarse moulding sand 20 parts, flour 1 part, sea coal 2 1/2 parts, wet with molasses water.

No. 2. Millville gravel 1, fire sand 1, coarse moulding 3, flour 1/3, sea coal 1/4; wet with molasses water. Black wash before drying with Plumbago 5 parts, talc 1 part, charcoal 1 part, mixed with molasses water. Molasses 1 and water 8 to 10 parts. Used on large valves, elbows, planer beds, etc.

CORE SAND MIXTURES

Aluminum and Light Brass

Silica or lake sand,	30 parts.
Moulding sand,	10 parts.
Linseed oil,	1 part.

Temper with water.

Fine gray bank or beach sand	10 parts.
Brass moulding sand	5 parts.
Rye flour	1 part.

Mix well and pass through No. 12 riddle while dry, then temper with weak molasses water.

Beach or fine bank sand	2 parts.
New brass moulding sand	1 part.
Gangway sand	1 part.

Have the sand quite dry and temper with molasses water. (molasses 1, water 8). Bake with care.

Glue Core

Dissolve 1 part of Lepage's liquid glue in 5 parts of warm water. Use fine dry beach sand and temper quite damp with the glue water. The dampness of the sand determines the hardness and strength of core. Bake with care. Glue cores soften if left in mould too long.

CORE SAND MIXTURES

Glue Cores. Light Small Work

Fine bank lake or beach sand and Gangway equal parts. Temper with the following: 1 lb. granulated glue dissolved in 12 quarts hot water.

Rosin Cores

Bench sand	8 parts.
Beach sand	8 parts.
Ground rosin	1 part.

Temper with water.

Small Cores. Jacket—Port—Valve, Etc.

Lake or silica sand	20 parts.
Bench moulding sand	10 parts.
Linseed oil	1 part.

Temper with molasses water.

Medium Size Cores. Cylinder Jackets, Etc.

Beach sand	14 parts
New moulding sand	6 parts

Mix together equal parts of dexterine and soy bean oil; add to sand 1 part.

Temper with water.

Large Solid Cores. Cylinder, Etc.

Sharp or bank sand	20 parts
Gangway sand	8 parts
Moulding sand	5 parts
Rosin	1 part

Dampen to suit with water.

CORE SAND MIXTURES

Large Size Cylinders, Columns, Etc.

Coarse bank sand	11 parts
Gangway and old cores	9 parts
New side floor moulding	5 parts
Black tar compound	1/2 part
Rye flour	1/2 part

Temper with clay water.

Large Cyl. and Jacket Cores

Jersey or Millville gravel	8 parts
Old dry sand	8 parts
Rosin	1/2 part
Rye flour	1/2 part

Temper with clay water.

VENTLESS CORES

For cores nearly surrounded by metal and very difficult to vent the following mixture is being used successfully without venting.

Mix twenty parts of beach sand and one part of Phil Smith's Phelim core oil together in a thorough manner and place on oven floor or in some place where the heat is just sufficient to steam the sand thoroughly with the oil for about ten hours. When cold make cores and dry same as linseed oil. Black wash well and when placing in mould break skin on the prints or supports drawing vent wire through cope drag or joint same as when core is vented. Rods are seldom necessary.

Cupola Breast Core

Crushed fire brick four parts
Moulding sand one part
Temper with Linseed oil.

Or

Bank sand three parts
Silica sand one part
Temper with Linseed oil.

Glucose	3 lbs.
Flour	8 ounces
Brown sugar	2 ounces
Alum	1/2 ounce

Mix in one gallon hot water and use 1 part to 20 parts of core sand. If sand is not wet enough to work, dampen with plain or weak molasses water.

Wax and Composition Vents

Warm paraffine wax in hot water and force through vent machine.

Equal parts of beeswax and rosin. Melt the wax and stir in the powdered rosin. Mix thoroughly. Warm and force through vent machine.

Core Paste

Rye or wheat flour mixed with water. If boiled or mixed with molasses strength is added.

Core Putty

Moulding sand five parts, plumbago one part; dampened with molasses water.

Anchor Cores in Anvil Blocks

Where core is surrounded with a very heavy thickness of metal and there is danger of melting it wrap the core with asbestos wicking or fasten sheets of asbestos about it with heavy wrought iron wire.

Use a piece of wrought iron pipe the inside diameter of which is the same as size of hole desired. Clean and tin the pipe, then ram the inside with a facing made of fire sand and sea coal.

Iron cores and chills must be free from moisture rust and dirt.

Chill Wash

Dissolve 1/2 lb. of rosin in alcohol, thicken to suit with soapstone.

An iron screw well coated with this mixture can be removed from casting with ease.

Plumbago mixed with lard oil rub on chill. Plumbago mixed with molasses or glue water is often used.

Dip Iron core in silicate of soda or oil or shellac and cover with fine sharp sand. For iron moulds used in casting brass or bronze use lard oil.

SAND MATCHES, FOLLOW BOARDS, ETC.

Plaster of Paris

Sieve the plaster into the water until it is of the right consistency to run well. Oil the patterns.

Connecticut Clay Match

Moisten and work into the condition of stiff putty any good plastic clay. Next flatten out into a form the shape of the match frame and about one inch thick. This is oiled and placed over the patterns which have been previously arranged in nowel with parting carefully made. Tuck the clay firmly all about the patterns, being careful to press it into all corners. After this is done ram up remainder of match frame with moulding sand. Fasten on bottom board roll over, remove nowel and finish match.

The advantage of a clay follow board is that light gated patterns rest evenly and firmly on them without rocking. The right degree of dampness must be maintained at all times.

Fine dry, sharp sand	20 parts
Litharge	1 part

Raw linseed oil enough to temper as damp as moulding sand in use.

Iron filings or fine cast iron chips	1/2 part
Litharge	1/4 part
Dry fine moulding sand	10 parts

Put through No. 12 riddle and temper quite damp with linseed oil. After follow boards are finished spray surface with the oil and dry slowly.

Cement Follow Board

Portland cement	2 parts
Plaster of Paris	1 part
Fine sharp sand	1 part
Water	3 parts

Warping—To Control

1. Use an iron mixture with the least possible amount of shrinkage.
2. Make mould in such a way that casting will cool evenly. Strip heavy sections or pour hot iron near light parts to equalize cooling.
3. Place weights on parts which tend to rise.
4. Leave copes on light plates and free the sand around risers and sprues or remove them.
5. Make pattern out of line and let contraction pull it straight.

To Control Contraction

Decrease Sulphur, Manganese and combined carbon. Leaving casting in mould until completely cold often suffices.

Blow Holes To Control

When caused by the iron the sulphur is usually too high. An increase of manganese and pouring at a higher temperature help to remedy this trouble. Too much dampness in moulds, cores or chills often produce them. Mould rammed too hard or sand too fine and close also cause blow holes.

Shrinkage, To Control

1. Use high graphatic low sulphur, soft iron.
2. Increase the pressure on mould by using deep copes or high pouring heads.
3. Use feeding heads which will remain fluid until casting is solid.
4. Use chills on heavy parts.
5. Churn casting through riser using hot iron to feed up with.
6. Keep risers and shrink heads open with thermit pieces of aluminum or hot iron. Covering risers with crushed charcoal or sand will help keep them liquid.
7. Use an iron mixture having a low percentage of phosphorus.

Casting One Metal Upon Another

The metal which is to be surrounded by molten iron or other molten metal must be absolutely free from moisture, rust or other foreign substance. Inserts are often coated with silicate of soda, red lead and oil or tinned, all of which is unnecessary provided the metal insert is clean, dry and hot when the molten metal comes in contact with it. Hydrofluoric acid or the sand blast should be used to clean the metal upon which the molten metal is to be poured.

Scabbed Moulds

Are caused by using sand that is to wet or fine and close or is not properly vented. Avoid hard ramming and too much slicking.

Drops and Drawn Down Copes

Are caused by using sand that is old and burned out or too dry.

Bars too far removed from face of mould not enough gaggers and improper venting are other causes.

Leaving the risers open while pouring is bad practice except on light, thin work. It releases the air pressure and permits the sand to leave the face or cope of mould more easily.

Crushes

Result from imperfect mould joints and the use of old worn out flasks the joints of which do not match.

Rat Tails

These depressed lines and indentations are caused by the use of old burned out sand the bond of which is destroyed by repeated use. Add new sand to the heap and they usually disappear. Light bag facings which float and run before the metal must be avoided.

To Determine Weight of Casting From Weight of Pattern

Pattern weighing one pound when cast of the following metals will weigh:

	W. Pine	White Wood	Bay Wood	Cherry
Aluminum ...	5.	4.	3.5	4.
Y. Brass.....	18.5	19.	15.	18.
Bronze	19.	19.5	18.5	15.
Iron.....	15.5	16.	15.	12.
Lead.....	26.	26.5	26.	22.
Tin.....	15.	15.5	15.2	12.5
Zinc.....	15.	14.5	15.	12.

Make allowance for core prints and metal on pattern, etc.

Shrinkage of castings made in green sand:

Iron from 1/16 to 3/16 average 1/10 inch per foot.

Steel about	1/4 inch per foot
Malleable iron	1/8 inch per foot
Brass, light	11/64 inch per foot
Brass, heavy	10/64 inch per foot
Bronze	9/64 inch per foot
Lead	5/64 inch per foot
Tin	4/64 inch per foot
Zinc	6/64 inch per foot

Aluminum (casting) 11/64.

NON-SHRINKING

White Metal Mixtures for Patterns

Tin Parts	Zinc Parts	Lead Parts	Antimony Parts	Bismuth Parts	
1	1				
1	2				Melt, stir well and pour these mixtures at a low temperature
30	17		¾		
15			1		
7		2	1		
3		5	1	2	
3		5	1		

Aluminum Mixtures for Patterns

Aluminum	Zinc	Copper	
92 Parts	Parts	8 parts	No. 12 Alloy
90 "	8 "	2 "	
88 "	12 "		Make allowance for shrinkage of about $\frac{3}{16}$ per ft.
80 "	20 "		
75 "	25 "		

Composition Pattern Mixture

Copper 16, Tin 1, Zinc 1, Lead 1.

PATTERN VARNISH

For Wood Patterns

Use gum shellac dissolved in grain or denatured alcohol. To color black use lampblack or black aniline soluble in alcohol. For red use Indian red powder. Copal varnish requires a longer time to dry but is more durable.

Color to suit same as shellac.

Pattern Varnishes

Red iron oxid varnish for wood or metal patterns.

First apply a priming coat of either orange or black shellac varnish. Then add enough dry red iron oxid to the orange shellac to give a good body and apply to pattern. This will dry very hard and produce a nice hard smooth surface.

Pattern Filler

For filling holes of any description on wood patterns.

Melt one lb. of rosin and 1-2 lb. of beeswax together, then cut into shavings 1-2 lb. of common yellow soap and mix with the hot beeswax and rosin. When mixed thoroughly add 4 lbs. of whiting, stirring continually. Cool enough to handle and roll into sticks 3-4″ diam. and 6″ to 8″ long.

An alcohol lamp flame will cause it to melt and run into the holes, checks or cracks in the pattern which are to be filled.

For Iron Patterns

Heat the pattern sufficient to melt beeswax and rub well into grain of metal.

Bayberry Wax

Make a soft paste by mixing or cutting the wax with benzine or turpentine. Apply with clean woolen cloth to pattern and rub to a polish. Keep the paste in an air tight box or can.

Iron Filler or Cement

Iron filings put through 60 mesh sieve 16 parts
Plaster of paris 16 parts
Gum Arabic powdered 3 parts
Color to suit with lamp black.

CRUCIBLES, DIMENSIONS AND CAPACITY

Nos.	Height Outside	Diam't'r at top Outside	Diam't'r at bilge Outside	Diam't'r at b't'm Outside	Gallons	Quarts	Pints
	Inches	Inches	Inches	Inches			
10	7 3/8	5 7/8	6 1/4	4 1/2		2	0
12	8	6 1/2	7	5		2	1
14	8 5/8	7	7 1/2	5 1/2		3	0
16	9 1/4	7 3/8	7 3/4	5 3/4		3	1
18	9 3/4	7 5/8	8	5 7/8	1	0	0
20	10 1/2	7 3/4	8 1/2	6 1/8	1	0	1
25	11	8 3/8	9	6 1/4	1	1	0
30	11 5/8	8 3/4	9 1/2	6 3/4	1	2	1
35	12	9	9 3/4	7 1/4	1	3	1
40	12 5/8	9 1/2	10 1/8	7 1/2	2	1	0
45	13	9 7/8	10 1/2	7 5/8	2	2	0
50	13 3/4	10 1/4	11 1/4	8	2	3	1
60	14	10 1/2	11 1/2	8 1/4	3	0	1
70	14 1/2	10 3/4	12	8 1/2	3	2	1
80	15 1/2	11 1/2	12 5/8	9 1/4	4	0	0
90	15 3/4	11 5/8	12 7/8	9 1/2	4	1	1
100	16 1/2	12	13 1/4	9 3/4	4	3	1
125	17 1/2	12 3/8	14 1/8	10	6	0	0
150	19 1/4	13 1/4	15	10 3/4	7	2	0
200	20 1/2	15	16 1/2	11 1/2	9	3	1
225	21	15 1/2	17 3/8	11 3/4	10	3	0
250	22 1/2	15	17	12 3/4	11	1	0
300	23 3/8	16 7/8	18	12	13	0	0
400	24	17 1/2	19 1/4	14 1/2	15	0	0

The capacity is usually 3 lb. per number for Brass or Bronze.

ALUMINUM CASTINGS

Al.	Zinc.	Copper	Phos. Copper	Magnesium	
92		8			No. 12 Alloy A1 for general work
90		10			Stiff and strong works well
85	15				Works well for general work
88	10		2		A strong metal
90	5			5	Magnalium
85	5			10	"

Aluminum Solders

Melt in separate crucibles, 1 of tin and 4 of zinc: pour together, mix well, and pour into pencil shapes.

Tin 11 parts, zinc 4 parts, aluminum 1 part Phosphor tin 1, zinc 11, tin 29 and aluminum1part.

Copper may be added to molten aluminum by the use of clean sheet copper or wire.

Heat the aluminum to about 1300 F. and it will dissolve the sheet or wire rapidly.

Hardener or temper metal for aluminum: Melt 50 lbs. of copper and just before it is all melted start adding 50 lbs. of aluminum. The al. will raise the heat sufficient to melt the remaining copper. Stir well with plumbago stirrer and pour into ingots. 16% of the temper metal will produce No. 12 alloy.

ALUMINUM BRONZES

App. Melting Point 1700 F.

Aluminum Bronze

Copper	Aluminum	Zinc	Phosper Tin
85	1	12	2
85	10	1	4
90	2	6	2
90	7	3	
92	6	2	
90	10		Tensile Strength 70000 lbs.

Melt the copper under a cover of charcoal and glass and introduce the aluminum as soon as copper becomes fluid.

Use skim gates and pour rapidly from bottom of mould in such a manner as to cause the least amount of agitation of metal.

Large risers and chills are necessary on heavy parts.

Keep all risers closed air tight.

Flux with one ounce of chloride of manganese per 100 lbs. when metal is ready to remove from fire.

1% of manganese copper helps to produce clean castings.

ACID RESISTING METALS

Approximate Melting Point 1735 F.

Cop.	Tin	Zinc	Lead	
85	10		5	Blue vitrol mine water
78	7		15	Blue vitrol mine water
86	5	3	6	Paper mill (Sulphite)
85	6	3	6	Paper mill Screen Plates
84	6		10	General
	Antimony			
75	5		20	Excellent acid metals when possible to use
	15		85	

BEARING METALS, BRONZES

Appro. Melting 1735 F.

		Nickel		
65	4	1	30	Plastic Bronze
85	5	Phos.	10	Brass Rolling Mill
79	10	1	10	R. R. Engine
		Anti-mony		
70	9	1	20	R. R. Car
77	8		15	Auto Truck

When lead content is high stir well and pour at low temperature. The addition of 1 per cent of nickel or 1 1/2% sulphur stirred well into the copper helps to prevent lead sweat.

MANGANESE BRONZE
Melting Point 1600 F.

Copper	Zinc	Tin	Manganese	Iron	Aluminum
56	41.25	.75	.25	1.25	.50
58	40.		1.		1.
56	38.	1	manganese copper 4		1.

Melt copper carefully under charcoal. Add the manganese copper.

To introduce iron use tin plate.

Heat the zinc before placing in crucible and add slowly to prevent chilling the bath. When zinc is all in add the aluminum and tin. Stir well and when molten metal flares zinc fumes remove from furnace and pour. Use large risers and chills to overcome shrinkage.

Pour from bottom when possible. The metals used should be the best.

Tensile strength about 70000 lbs.

Phosper Bronze
Melting Point 1800 F.

Copper	5% Phos. Tin	10% Phos. Copper	Tin	Lead	
80	10			10	Bearings
85	5			10	Acid Metal
90		4	6		Gears
88	8			4	Bushings
90	10				Strong and tough

Use large gates and risers.

Pour cold and black mould well with plumbago.

YELLOW BRASS MIXTURES

Approximate Melting Point 1645 F.

Copper	Tin	Zinc	Lead	
50		50		Art Castings, Panels, Locks, etc.
60		40		Muntz Metal, Bolts & Nuts
62	1	37		Naval Brass
62		38		Common High Brass
65	1½	29	1½	Passenger Car Trimmings
66		32	2	Plumbers' Goods
75	2	22	1	General Work
86		13	1	Brazing Metal

Steam Metal Appro. Melting Point 1780 F.

86	6	6	2	Steam Metal Flanges, Elbows, etc.
84	7	4½	4½	" " " " "
88	10	2		" " " " "
87	6	5	2	" " " " "
90	4½	3½	2	Small Valve Bodies
86	7½	3½	3	Half inch to six
80	7	10	3	inches diameter

Red Metal or Composition General Work, Melting Point 1780 F.

80	6.5	6.5	6.5	Ounce metal Low pressure steam and general work
80	10	5	5	More dense and strong
87	8	4	1	General purpose
90	8	2		Hydrant and valve stems
88	9	3		Gun Metal
85	10	5		Pumps and liners
80	10	10		Propellers
88	10		2	Pump liners, acid water. Melt all new metal and pig then use the remelted metal for the castings

Boronized Copper Castings

For high electrical conductivity use two clean crucibles. In one melt Lake copper well covered with charcoal to 2400 deg. F. Have the second crucible red hot and after placing 1% of Boron flux in it pour the molten copper and charcoal into second crucible. Stir well with plumbago skimmer. The metal may be cooled to proper pouring heat with gates and risers from previous casts. When cool enough to pour skim clean and pour quickly. Shrinkage is about the same as aluminum or manganese bronze.

Melt good grade of casting copper under charcoal. When thoroughly melted pole it with hard wood stick until oxygen is reduced. Then add from 2 to 5% zinc. Or 1 to 1 1/2% of silicon.

Phosper copper is also used.

10% of 15% phosper copper being usually sufficient.

Coloring Brass and Bronze Castings

Use metal free from iron or other impurities and leave castings in the mould until they attain the desired color. Then remove quickly and set the color by plunging into water.

The length of time to leave in mould must be determined by experience. Thickness of casting, heat at which it was poured and the metal in mixture are all to be taken into consideration. Valve bodies running from ½″ to 2″ diam. usually require 10 to 30 minutes to cool before dipping in water.

Acids Used for Cleaning Castings and Remarks

Good ventilation and protection from the acid and fumes must be provided.

Aqua Regia is composed of one part Nitric and three parts Hydrochloric acid. It is the strongest solvent known.

Nitric acid or aqua fortis is a colorless liquid very powerful and active. The gases are poisonous.

Hydrochloric Acid. Known also as muriatic. Spirit of salt and marine acid is yellowish in color, has a sharp penetrating taste and smell. The fumes produce suffocation.

Acid Pickle for Iron Castings

Hydrofluoric acid in a concentrated state is very strong and powerful. The standard commercial solution on the market usually contains 30% acid and is diluted for use with about 20 parts water. Unlike sulphuric acid it acts upon the sand direct. As it attacks lead, glass or porcelain it is usually mixed in a wooden vat well lined with a coating of tar or asphaltum.

Should any of the acid or pickle come in contact with the skin wash at once with diluted ammonia water or apply linseed oil and lime water.

As the pickle produces a smooth, clean surface on cast iron it is used on work that is to be polished or nickled.

Always pour the acid slowly into the water.

For cleaning cast iron that is to be nickel plated use the following:

Hydrofluoric acid	1 part
Sulphuric acid	3 parts
Water	4 parts

Leave in pickle about 20 minutes.

Remove and rinse in lime water composed of lime 1, water 20 parts.

Acid Pickles for Iron Castings

Sulphuric acid (Oil of vitrol) is reduced or mixed with from two to ten parts of water, depending upon strength of the acid and the thickness of sand scale to be removed. Use a lead lined tank or earthenware jar. Pour the acid slowly into the water and stir well.

Dip the work in the pickle and let soak a moment. Then remove and place in drain rack until sand becomes loose. It can then be washed off with clean water.

Acid Pickles for Brass Castings

Nitric acid one part
Sulphuric acid one part
Muriatic one eighth part
To clean and brighten

If work is too dull in color add muriatic. If too white add nitric. Rinse in hot, clear water.

Bright Yellow Brass Dip

Sulphuric acid three quarts
Nitric acid two quarts
Salt one tablespoon

Bright Dipping Pickle

Sulphuric acid one gallon
Muriatic acid one half pint
Nitric acid one half pint
Water one half pint
Nitre 6 lbs.

Fumeless Acid Dip

Water five lbs.
Sulphuric acid ten lbs.
Saltpetre two lbs.

Dip for Brass Casting to be Tinned

Heat castings and dip in muriatic acid cut with zinc, then dip into molten tin. Again dip in the acid and remove surplus tin by shaking.

FLUXES USED IN BRASS FOUNDRY

Brass, Bronze and Copper Castings

Crushed charcoal enough to thoroughly cover the metal. Coke dust, saw dust and tan bark are also used.

Glass enough to produce a fluid slag covering over the metal.

Salt one tablespoon to 50 lbs. of copper.

Aluminum

Zinc cloride tablespoon to 50 lbs. metal. Place on molten metal and stir in. Do not breathe fumes.

Babbit Metals and All Zinc and White Metals

Sprinkle surface with Sal Ammoniac or tallow and rosin.

Borings and Sweepings

Plaster of paris.

German Silver

Plaster of paris and nitre equal parts. Stir well into metal.

FLUXES AND PURIFIERS OF IRON

Fluorspar Marble Chips, Lime Stone or Oyster Shells

Use from 25 to 50 lbs. of either of the above per ton of iron. Vary the amount used until the slag attains the right degree of fluidity. Place the flux on third and each succeeding charge of coke.

Aluminum

.2 to .1.% used in ladle to remove gases and add life to the iron. It increases the softness and strength of white iron and decreases the strength of soft iron.

Crominum

About 1% used in ladle to increase the density and strength.

Fero Manganese

Used in cupola or ladle to remove sulphur, close the grain and make castings more sound and clean. It toughens the chill on chilled work.

FLUXES AND PURIFIERS OF IRON

Titanium

2% of 10% Fero Titanium cleanses the iron of oxygen and nitrogen, adds to the strength and lessens the tendency to chill.

Vanadium

.1% used in ladle to toughen, clean and strengthen iron.

Cost of Iron Castings

The labor cost of producing 100 lbs. of castings in foundry's well equipped for producing the following lines is taken from actual records for 1914: Coke per cwt. 6 1-2c, Sand 3c, facings, clays, core binders, etc., 4c. These items remain fairly constant while iron labor and indirect vary. The following figures represent labor cost only, and are obtained by dividing the foundry pay roll by the lbs. of good castings produced. Indirect and all other charges being omitted.

Pump Shop Capacity 40 ton. Labor cost per 100 lbs.,	$ .90
Power Transmission, Pulleys, Boxes, Hangers, etc. Labor cost per 100 lbs.,	1.03
Jobbing Shop 30 ton, half light and heavy,	1.08
Electrical Transformer and Light Motor, 50 ton capacity,	1.07
Electrical Heavy Motor Turbine Engine, etc.,	1.01
Corliss Engine Air Compressors Rock Drills, Capacity of Shop 80 ton,	1.19
Paper Mill Machinery, Rag Engine, Pulp Grinders, etc., capacity 12 ton,	.92
Stone Working Machinery, rubbing beds, Stone Planers, Derrick Castings, 20 ton capacity,	.73
Tool Work Shop, Lathes, Planers, Milling Machinery, capacity 40 ton,	.82
Printing Press Work, 12 ton shop,	1.11
Valve and Hydrant Shop, capacity 30 ton,	.88
Wages Average for Moulders,	$3.00
Core Makers,	2.50
Helpers,	1.80

Estimating on the Cost of Castings

Many cost accountants use the following form or schedule when figuring on new work Coke $6.50 and Sand $2.50 in fdy. bins:

	Per cwt.	Per ton
Coke	$.065	
Sand	.030	
Sundries	.040	
Flasks and Rigging	.050	
Iron	.750	
Shrinkage	.040	
Moulding	.400	
Cores	.300	
Discount 6%	.050	
Cleaning	.300	
Shipping Fgt.		
Overhead	.500	
Profit	.250	

For Small Orders and Single Castings

Foundries are rapidly adopting the method used in machine shops on repair work. The customer pays for stock used and time spent on job.

Strength of Metals Transverse and Tensile

Per Sq. Inch in Lbs.	Trans-verse	Tensile
Cast Aluminum		20000
" Aluminum Bronze		75000
" Gov. Bronze 88-10-2		33000
" Phos. "		50000
Mang. "		65000
Tobin "		66000
5% Silicon "		70000
Cast Copper		27000
Iron-Cast Soft	2100	20000
" Medium	2300	22000
" Hard	2500	23000
" Malleable	3000	40000
" Lead		1600
Steel Cast		70000
Steel Tool		100000
" Semi 20%		30000
Tin		4000
Zinc		6000

To Find the Weight of Castings From Measurements Given in Inches

If square or rectangular multiply length by breadth by thickness, which gives the total number of cubic inches. Then multiply total number of cubic inches by the wt. of one cubic inch of the metal to be used.

Round Plates, Solid Round Columns or Shafts, Capacity of Ladles, Etc.

Square the diameter and multiply by .7854 which gives the number of cubic inches for one inch of thickness. Again multiply by the number of inches in length or depth and lastly by the weight of one cubic inch of the metal to be used.

Cylinders, Pulley or Balance Wheel Rims, Straight Pipes, Etc.

To the inside diameter add the thickness of one side and multiply by 3.1416 then by the thickness, again by number of inches in length or depth. This gives total number of cubic inches contained which must again be multiplied by the weight of one cubic inch of the metal to be used.

Balls

Cube the diameter and multiply by .5236. The result will be the number of cubic inches contained in pattern. This multiplied by the weight of one cubic inch of metal to be used gives the weight of ball.

To find the weight per cubic inch specific gravity being given, multilpy specific gravity by .036085 Wt. per cu. ft. Multiply specific gravity by 62.425.

Diameter, Weight and Capacity of Cast Iron, Lead, Brass, Copper and Steel Balls

Diam.	Capacity Cu. Inches	Cast Iron	Lead	Brass	Copper	Steel
1 "	.5236	.1365	.2147	.155	.166	.146
1 1/4	1.0227	.2666	.4195	.306	.327	.286
1 1/2	1.7672	.4607	.7248	.526	.563	.495
1 3/4	2.8062	.7316	1.151	.841	.897	.785
2	4.1888	1.092	1.718	1.25	1.33	1.13
2 1/4	5.9641	1.554	2.446	1.78	1.90	1.66
2 1/2	8.1812	2.132	3.355	2.4	2.6	2.26
2 3/4	10.8892	2.838	4.466	3.2	3.45	3.04
3	14.1372	3.685	5.798	4.2	4.5	3.9
3 1/4	17.9742	4.685	7.372	5.4	5.6	5.01
3 1/2	22.4493	5.852	9.207	6.7	7.14	6.2
3 3/4	27.6117	7.198	11.32	8.2	8.8	7.7
4	33.5104	8.736	13.74	9.9	10.6	9.27
4 1/4	40.1945	10.47	16.48	12.	12.86	11.25
4 1/2	47.7130	12.43	19.56	14.2	15.2	13.3
4 3/4	56.1152	14.62	23.01	16.8	17.9	15.7
5	65.4500	17.06	26.84	19.5	21.	18.5
5 1/4	75.7675	19.75	31.07	22.7	24.2	21.2
5 1/2	87.1139	22.71	35.72	25.9	27.7	24.4
5 3/4	99.5413	25.95	40.82	29.8	31.8	27.87
6	113.097	29.48	46.38	33.6	36.	32
6 1/4	127.702	33.29	52.37	38.3	40.8	35.75
6 1/2	143.793	37.48	58.97	42.7	45.7	40.
6 3/4	161.031	41.98	66.04	48.3	51.52	45.
7	179.594	46.82	73.66	53.3	57.	50.5
7 1/4	199.532	52.01	81.83	59.8	63.8	55.8
7 1/2	220.893	57.58	90.59	65.7	70.3	62.
7 3/4	243.727	63.53	99.96	73.1	77.9	68.23
8	268.083	69.88	109.95	79.4	85.	75.2
8 1/4	294.009	76.64	120.58	88.2	91.14	82.3
8 1/2	321.555	83.82	131.88	95.6	102.3	90.
8 3/4	350.771	91.44	143.86	105.2	108.7	98.2
9	381.704	99.51	156.55	113.	121.	107.
9 1/2	448.921	117.03	184.12	133.6	143.	126.
10	523.600	136.50	214.75	155.	166.	146.
10 1/2	606.132	157.89	248.51	180.	193.	169.
11	696.911	181.68	285.83	207.5	222.	195.
11 1/2	796.329	197.04	326.49	236.4	253.	222.
12	904.780	235.87	371.09	278.	288.	254.
13	1150.35	299.89	471.81	345.	368.	312.
14	1436.758	374.56	589.28	430.	458.	402.
15	1767.150	460.69	724.79	530.	565.	494.
16	2144.665	559.11	879.63	643.	686.	600.
17	2572.44	670.63	1055.	771.	823.	720.
18	3053.63	796.	1252.	915.	976.	854.
19	3591.37	936.	1473.	1077.	1149.	1005.
20	4188.80	1092.	1718.	1256.	1340.	1172.

Conversion Table for Reducing to Parts of One Pound i.e. Ounces and Drams, Any Mixture Written in Percentages

It will be noticed that the table covers only fifty pounds but by selecting two figures from the table equalling the figure to be reduced no difficulty need be encountered.

The two examples further explain its use.

		Ounces	Drams
Copper	80. = 40 =	6	6
	40 =	6	6
Tin	6.	1	
Zinc	7.5	1	3
Lead	6.5	1	1
Pounds	100.0	15	16 = 1 oz
		1	
		16 = 1 lb.	

		Ounces	Drams
Copper	3.		8
Tin	42	6	12
Lead	38	6	1
Antimony	17	2	12
		14 oz	33 = 2 oz and 1 dram
		2 oz	
		16 oz	

Percentage	Oz. Dr.	Percentage	Oz. Dr.	Percentage	Oz. Dr.	Percentage	Oz. Dr.
.39	1	12.89	2–1	25.39	4–1	37.85	6–1
.78	2	13.28	2–2	25.78	4–2	38.28	6–2
1.17	3	13.67	2–3	26.17	4–3	38.67	6–3
1.56	4	14.06	2–4	26.56	4–4	39.06	6–4
1.95	5	14.45	2–5	26.95	4–5	39.45	6–5
2.34	6	14.84	2–6	27.34	4–6	39.84	6–6
2.73	7	15.23	2–7	27.73	4–7	40.23	6–7
3.13	8	15.62	2–8	28.13	4–8	40.62	6–8
3.52	9	16.01	2–9	28.52	4–9	41.02	6–9
3.91	10	16.41	2–10	28.91	4–10	41.41	6–10
4.30	11	16.80	2–11	29.30	4–11	41.79	6–11
4.69	12	17.19	2–12	29.69	4–12	42.19	6–12
5.08	13	17.58	2–13	30.08	4–13	42.54	6–13
4.47	14	17.97	2–14	30.47	4–14	42.97	6–14
5.86	15	18.36	2–15	30.86	4–15	43.36	6.15
6.25	1–0	18.75	3–00	31.25	5–00	43.75	7–00
6.64	1–1	19.14	3–1	31.64	5–1	44.14	7–1
7.03	1–2	19.53	3–2	32.03	5–2	44.53	7–2
7.42	1–3	19.92	3–3	32.42	5–3	44.92	7–3
7.81	1–4	20.31	3–4	32.81	5–4	45.31	7–4
8.20	1–5	20.70	3–5	33.20	5–5	45.70	7–5
8.59	1–6	21.09	3–6	33.59	5–6	46.09	7–6
8.98	1–7	21.48	3–7	33.98	5–7	46.48	7–7
9.38	1–8	21.88	3–8	34.37	5–8	46.87	7–8
9.77	1–9	22.27	3–9	34.69	5–9	47.27	7–9
10.16	1–10	22.66	3–10	35.16	5–10	47.66	7–10
10.55	1–11	23.05	3–11	35.55	5–11	48.05	7–11
10.94	1–12	23.44	3–12	35.94	5–12	48.44	7–12
11.33	1–13	23.83	3–13	36.33	5–13	48.83	7–13
11.72	1–14	24.22	3–14	36.71	5–14	49.22	7–14
12.10	1–15	24.61	3–15	37.11	5–15	49.61	7–15
12.50	2–0	25.00	4.00	37.50	6–00	50.00	8–00

Diameter, Circumference, Area and Weight of Round Sections from ½ Inch to 36″ Diameter When Cast of Aluminum, Bronze Brass or Cast Iron

To find the weight of pipe or cylinder subtract the weight of inside diameter from weight of outside diameter and multiply by total length in inches.

No. 12 aluminum alloy 8% copper wt. per cu. in. .102. Bronze copper 88, tin 10, zinc 2, wt. per cu. in. .3195.

Brass copper 70.

Zinc 30 , wt. per cu. in. .303.

Cast iron wt. per cu. in. .2604.

Diam.	Circum.	Area	Aluminum	Bronze	Cast Brass	Cast Iron
½″	1.5708	.1963	.02002	.0627	.0595	.0511
⅝	1.9635	.3068	.03129	.0980	.0929	.0799
¾	2.3562	.4417	.04505	.1411	.1338	.1150
⅞	2.7489	.6013	.06133	.1921	.1822	.1566
1.	3.1416	.7854	.08011	.2509	.2380	.2045
⅛	3.5343	.9940	.1014	.3176	.3012	.2588
¼	3.9270	1.227	1.252	.3920	.3718	.3195
⅜	4.3197	1.484	.1514	.4741	.4497	.3864
½	4.7124	1.767	.1802	.5646	.5354	.4601
⅝	5.1051	2.073	2.114	.6623	.6281	.5398
¾	5.4978	2.405	2.453	.7684	.7287	.6263
⅞	5.8905	2.761	2.816	.8821	.8366	.7190
2.	6.2832	3.141	3.204	1.004	.9517	.8179
⅛	6.6759	3.546	3.617	1.133	1.074	.9234
¼	7.0686	3.976	4.056	1.270	1.205	1.035
⅜	7.4613	4.430	4.519	1.415	1.342	1.154
½	7.8540	4.908	5.006	1.568	1.487	1.278
⅝	8.2467	5.411	5.519	1.729	1.640	1.409
¾	8.6394	5.939	6.058	1.898	1.800	1.547
⅞	9.0321	6.491	6.621	2.074	1.967	1.690
3.	9.4248	7.068	7.209	2.258	2.142	1.841
⅛	9.8175	7.669	7.822	2.450	2.324	1.997
¼	10.210	8.295	8.461	2.650	2.513	2.160
⅜	10.603	8.946	9.125	2.858	2.711	2.330
½	10.996	9.621	9.813	3.074	2.915	2.565
⅝	11.388	10.321	10.53	3.298	3.127	2.688
¾	11.781	11.045	11.27	3.529	3.347	2.876
⅞	12.174	11.793	12.03	3.768	3.573	3.071

Diam.	Circum.	Area	Aluminum	Bronze	Brass	Cast Iron
4.	12.566	12.566	12.82	4.015	3.807	3.272
1/8	12.959	13.364	13.63	4.270	4.049	3.480
1/4	13.352	14.186	14.47	4.532	4.298	3.694
3/8	13.744	15.033	15.33	4.803	4.555	3.915
1/2	14.137	15.904	16.22	5.081	4.819	4.141
5/8	14.530	16.800	17.14	5.368	5.090	4.375
3/4	14.923	17.721	18.08	5.662	5.370	4.615
7/8	15.315	18.665	19.04	5.963	5.655	4.860
5.	15.708	19.635	20.03	6.273	5.949	5.113
1/8	16.101	20.629	21.04	6.591	6.251	5.372
1/4	16.493	21.648	22.08	6.917	6.559	5.637
3/8	16.886	22.691	23.14	7.250	6.875	5.909
1/2	17.279	23.758	24.23	7.591	7.199	6.187
5/8	17.671	24.850	25.35	7.940	7.530	6.471
3/4	18.064	25.967	26.49	8.296	7.868	6.762
7/8	18.457	27.109	27.65	8.661	8.214	7.059
6.	18.850	28.274	28.84	9.034	8.567	7.363
1/8	19.242	29.465	30.05	9.414	8.928	7.673
1/4	19.635	30.680	31.29	9.802	9.296	7.989
3/8	20.028	31.919	32.56	10.20	9.671	8.312
1/2	20.420	33.183	33.85	10.60	10.05	8.641
5/8	20.813	34.472	35.16	11.01	10.45	8.977
3/4	21.206	35.785	36.42	11.43	10.84	9.318
7/8	21.598	37.122	37.86	11.86	11.25	9.667
7.	21.991	38.485	39.25	12.30	11.66	10.02
1/8	22.384	39.871	40.67	12.74	12.08	10.38
1/4	22.776	41.282	42.11	13.19	12.51	10.75
3/8	23.169	42.718	43.57	13.65	12.94	11.12
1/2	23.562	44.179	45.06	14.12	13.39	11.50
5/8	23.955	45.664	46.58	14.59	13.84	11.89
3/4	24.347	47.173	48.12	15.07	14.29	12.28
7/8	24.740	48.707	49.68	15.56	14.76	12.68
8.	25.133	50.265	51.27	16.06	15.23	13.09
1/8	25.525	51.849	52.89	16.57	15.71	13.50
1/4	25.918	53.456	54.53	17.08	16.20	13.92
3/8	26.311	55.088	56.19	17.60	16.69	14.34
1/2	26.704	56.745	57.88	18.13	17.19	14.78
5/8	27.096	58.426	59.59	18.67	17.70	15.21
3/4	27.489	60.132	61.33	19.21	18.22	15.66
7/8	27.882	61.862	63.10	19.76	18.74	16.11
9.	28.274	63.617	64.89	20.33	19.28	16.57
1/8	28.667	65.397	66.70	20.89	19.82	17.03
1/4	29.060	67.201	68.55	21.47	20.36	17.50
3/8	29.452	69.029	70.41	22.05	20.92	17.98
1/2	29.845	70.882	72.23	22.65	21.48	18.46
5/8	30.238	72.760	74.22	23.25	22.05	18.95
3/4	30.631	74.662	76.11	23.85	22.62	19.44
7/8	31.023	76.589	78.12	24.47	23.21	19.94

Diam.	Circum.	Area	Aluminum	Bronze	Brass	Cast Iron
10.	31.416	78.540	80.11	25.09	23.86	20.45
1/8	31.809	80.516	82.13	25.72	24.40	20.97
1/4	32.201	82.516	84.17	26.36	25.	21.49
3/8	32.594	84.541	86.23	27.61	25.62	22.01
1/2	32.987	86.590	88.32	27.67	26.24	22.55
5/8	33.379	88.664	90.44	28.33	26.87	23.09
3/4	33.772	90.763	92.58	29.00	27.50	23.63
7/8	34.165	92.886	94.74	29.68	28.14	24.19
11.	34.558	95.033	96.93	30.36	28.79	24.75
1/8	34.950	97.205	99.15	31.06	29.45	25.31
1/4	35.343	99.402	10.13	31.76	30.12	25.88
3/8	35.736	101.62	10.37	32.47	30.79	26.46
1/2	36.128	103.87	10.59	33.19	31.47	27.05
5/8	36.521	106.14	10.83	33.91	32.16	27.64
3/4	36.914	108.43	11.03	34.64	32.85	28.24
7/8	37.306	110.75	11.30	35.38	33.56	28.84
12.	37.699	113.10	11.54	36.14	34.27	29.45
1/8	38.092	115.47	11.78	36.89	34.99	30.07
1/4	38.485	117.86	12.02	37.66	35.71	30.69
3/8	38.877	120.28	12.27	38.43	36.44	31.32
1/2	39.270	122.72	12.46	39.21	37.18	31.96
5/8	39.663	125.19	12.77	40.00	37.93	32.60
3/4	40.055	127.68	13.02	40.79	38.69	33.25
7/8	40.448	130.19	13.28	41.60	39.45	33.90
13.	40.841	132.73	13.54	42.41	40.22	34.56
1/8	41.233	135.30	13.80	43.23	41.	35.23
1/4	41.626	137.89	14.06	44.06	41.78	35.91
3/8	42.019	140.50	14.33	44.78	42.59	36.59
1/2	42.412	143.14	14.60	45.73	43.37	37.27
5/8	42.804	145.80	14.87	46.58	44.18	37.97
3/4	43.197	148.49	15.15	47.44	44.99	38.67
7/8	43.590	151.20	15.42	48.31	45.81	39.37
14.	43.982	153.94	15.70	49.19	46.64	40.09
1/8	44.375	156.70	15.98	50.07	47.48	40.80
1/4	44.768	159.48	16.27	50.95	47.72	41.53
3/8	45.160	162.30	16.55	51.85	49.18	42.26
1/2	45.553	165.10	16.84	52.77	50.03	43.
5/8	45.946	167.99	17.11	53.67	50.90	43.74
3/4	46.338	170.87	17.43	54.59	51.77	44.49
7/8	46.731	173.78	17.73	55.52	52.66	45.25
15.	47.124	176.71	18.02	56.46	53.54	46.02
1/8	47.517	179.67	18.33	57.40	54.44	46.79
1/4	47.909	182.65	18.63	58.36	55.34	47.56
3/8	48.302	185.66	18.94	59.32	56.25	48.35
1/2	48.695	188.69	19.25	60.29	57.17	49.13
5/8	49.087	191.75	19.56	61.26	58.10	49.93
3/4	49.480	194.83	19.87	62.25	59.03	50.73
7/8	49.873	197.93	20.19	63.24	59.97	51.54

Diam.	Circum.	Area	Aluminum	Bronze	Brass	Cast Iron
16.	50.265	201.06	20.51	64.24	60.92	52.36
1/8	50.658	204.22	20.83	65.25	61.88	53.18
1/4	51.051	207.39	21.15	66.26	62.84	54.
3/8	51.444	210.60	21.49	67.29	63.81	54.84
1/2	51.836	213.82	21.81	68.32	64.79	55.68
5/8	52.229	217.08	22.14	69.36	65.78	56.53
3/4	52.622	220.35	22.48	70.40	66.77	57.38
7/8	53.014	223.65	22.81	71.46	67.77	58.24
17.	53.407	226.98	23.15		68.77	59.11
1/8	53.800	230.33	23.49	73.59	69.79	59.98
1/4	54.192	233.71	23.84	74.67	70.81	60.86
3/8	54.585	237.10	24.18	75.75	71.84	61.74
1/2	54.978	240.53	24.53	76.85	72.88	62.63
5/8	55.371	243.98	24.89	77.95	73.93	63.53
3/4	55.763	247.45	25.24	79.06	74.98	64.44
7/8	56.156	250.95	25.60	80.18	76.04	65.35
18.	56.549	254.47	25.96	81.30	77.10	66.26
1/8	56.941	258.02	26.32	82.44	78.18	67.19
1/4	57.334	261.59	26.68	83.58	79.26	68.12
3/8	57.727	265.18	27.05	84.73	80.35	69.05
1/2	58.119	268.80	27.42	85.88	81.45	70.
5/8	58.512	272.45	27.79	87.05	82.55	70.95
3/4	58.905	276.12	28.16	88.22	83.66	71.90
7/8	59.298	279.81	28.54	89.40	84.78	72.86
19.	59.690	283.53	28.92	90.59	85.91	73.83
1/8	60.083	287.27	29.30	91.78	87.04	74.81
1/4	60.476	291.04	29.69	92.99	88.19	75.79
3/8	60.868	294.83	30.07	94.20	89.33	76.77
1/2	61.261	298.65	30.46	95.42	90.49	77.77
5/8	61.654	302.49	30.85	96.65	91.65	78.77
3/4	62.046	306.35	31.25	97.88	92.82	79.77
7/8	62.439	310.24	31.64	99.12	94.01	80.79
20.	62.832	314.16	32.04	100.3	95.19	81.81
1/8	63.225	318.10	32.45	101.6	96.38	82.83
1/4	63.617	322.06	32.85	102.9	97.58	83.86
3/8	64.010	326.05	33.26	104.2	98.79	84.90
1/2	64.403	330.06	33.67	105.5	100.	85.95
5/8	64.795	334.10	34.08	106.7	101.2	87.
3/4	65.188	338.16	34.49	108.	102.46	88.06
7/8	65.581	342.25	34.91	109.3	103.7	89.12
21.	65.937	346.36	35.33	110.7	104.9	90.19
1/8	66.366	350.50	35.75	112.	106.2	91.27
1/4	66.759	354.66	36.18	113.3	107.5	92.35
3/8	67.152	358.84	36.60	114.6	108.7	93.44
1/2	67.544	363.05	37.03	116.	110.	94.54
5/8	67.937	367.28	37.46	117.3	111.3	95.64
3/4	68.330	371.54	37.90	118.7	112.6	96.75
7/8	68.722	375.83	38.33	120.1	113.9	97.87

Diam.	Circum.	Area	Aluminum	Bronze	Brass	Cast Iron
22.	69.115	380.13	38.77	121.5	115.2	98.99
1/8	69.508	384.46	39.21	122.8	116.5	100.1
1/4	69.900	388.82	39.66	124.2	117.8	101.2
3/8	70.293	393.20	40.11	125.6	119.1	102.4
1/2	70.686	397.61	40.56	127.	120.5	103.5
5/8	71.079	402.04	41.01	128.5	121.8	104.7
3/4	71.471	406.49	41.46	129.9	123.2	105.8
7/8	71.864	410.97	41.92	131.3	124.5	107.
23.	72.257	415.48	42.38	132.7	125.9	109.2
1/8	72.649	420.00	42.84	134.2	127.3	109.4
1/4	73.042	424.56	43.31	135.6	128.6	110.6
3/8	73.435	429.13	43.77	137.1	130.	111.7
1/2	73.827	433.74	44.24	138.6	131.4	112.9
5/8	74.220	438.36	44.71	140.1	132.8	114.1
3/4	74.613	443.01	45.19	141.5	134.2	115.4
7/8	75.006	447.69	45.66	143.	135.7	116.6
24.	75.398	452.39	46.14	144.5	137.1	117.8
1/8	75.791	457.11	46.63	146.	138.5	119.
1/4	76.184	461.86	47.11	147.6	140.	120.2
3/8	76.576	466.64	47.60	149.1	141.4	121.5
1/2	76.969	471.44	48.09	150.6	142.8	122.8
5/8	77.362	476.26	48.58	152.2	144.3	124.
3/4	77.754	481.11	49.7	153.7	145.8	125.3
7/8	78.147	485.98	49.57	155.3	147.3	126.5
25.	78.540	490.87	50.07	156.8	148.7	127.8
1/8	78.933	495.79	50.57	158.4	150.2	129.1
1/4	79.325	500.74	51.08	160.	151.7	130.4
3/8	79.718	505.71	51.58	161.6	153.2	131.7
1/2	80.111	510.71	52.09	163.2	154.7	133.
5/8	80.503	515.72	52.60	164.8	156.3	134.3
3/4	80.896	520.77	53.12	166.4	157.8	135.6
7/8	81.289	525.84	53.64	168.	159.3	136.9
26.	81.681	530.93	54.15	169.6	160.9	138.3
1/8	82.674	536.05	54.68	171.3	162.4	139.6
1/4	82.467	541.19	55.20	172.9	164.	140.9
3/8	82.860	546.35	55.73	174.6	165.5	142.3
1/2	83.252	551.55	56.26	176.2	167.1	143.6
5/8	83.645	556.76	56.79	177.9	168.7	145.
3/4	84.038	562.00	57.32	179.6	170.3	146.3
7/8	84.430	567.27	57.86	181.2	171.9	147.7
27.	84.823	572.56	58.40	182.9	173.5	149.1
1/8	85.216	577.87	58.94	184.6	175.1	150.5
1/4	85.608	583.21	59.49	186.3	176.7	151.9
3/8	86.001	588.57	60.03	188.	178.3	153.3
1/2	86.394	593.96	66.58	189.8	180.	154.7
5/8	86.786	599.37	61.14	191.5	181.6	156.1
3/4	87.179	604.81	61.69	193.2	183.3	157.5
7/8	87.572	610.27	62.25	195.	184.9	158.9

Diam.	Circum.	Area	Aluminum	Bronze	Brass	Cast Iron
28.	87.965	615.75	62.81	196.7	186.6	160.3
1/8	88.357	621.26	63.37	198.5	188.2	161.8
1/4	88.750	626.80	63.93	200.3	190.	163.2
3/8	89.143	632.36	64.50	202.	191.6	164.7
1/2	89.535	637.94	65.07	203.8	193.3	166.1
5/8	89.928	643.55	65.64	205.6	195.	167.6
3/4	90.321	649.18	66.22	207.4	196.7	169.
7/8	90.713	654.85	66.79	209.2	198.4	170.5
29.	91.106	660.52	67.37	211.	200.1	172.
1/8	91.499	666.23	67.96	212.9	201.9	173.5
1/4	91.852	671.96	68.54	214.7	203.6	175.
3/8	92.284	677.71	69.13	216.5	205.3	176.5
1/2	92.677	683.49	69.72	218.5	207.1	178.
5/8	93.070	689.30	70.31	220.2	208.9	179.5
3/4	93.462	695.13	70.90	222.1	210.6	181.
7/8	93.855	700.98	71.50	224.	212.4	182.5
30.	94.248	706.86	72.10	225.8	214.2	184.1
1/8	94.640	712.76	72.70	227.7	216.	185.6
1/4	95.033	718.69	73.31	229.6	217.8	187.1
3/8	95.426	724.64	73.90	231.5	219.6	188.7
1/2	95.819	730.62	74.52	233.4	221.4	190.3
5/8	96.211	736.62	75.14	235.4	223.2	191.8
3/4	96.604	742.64	75.75	237.3	225.	193.4
7/8	96.997	748.69	76.37	239.2	226.9	195.
31.	97.389	754.77	76.99	241.1	228.7	196.5
1/8	97.782	760.87	77.61	243.1	230.5	198.1
1/4	98.175	766.99	78.23	245.1	232.4	199.7
3/8	98.567	773.44	78.89	247.	234.4	206.4
1/2	98.960	779.31	79.49	249.	236.1	202.9
5/8	99.353	785.51	80.12	251.	238.	204.5
3/4	99.746	791.73	80.76	253.	239.9	206.2
7/8	100.38	797.98	81.39	255.	241.8	207.8
32.	100.53	804.25	82.03	257.	243.7	209.4
1/8	100.92	810.54	82.68	259.	245.6	211.1
1/4	101.31	816.86	83.33	261.	247.5	212.7
3/8	101.70	823.21	83.97	263.	249.4	214.4
1/2	102.10	829.58	84.62	265.1	251.3	216.
5/8	102.49	835.97	85.27	267.	253.3	217.7
3/4	102.88	842.39	85.92	269.	255.2	219.4
7/8	103.28	848.83	86.58	271.	257.2	221.
33.	103.67	855.30	87.24	273.3	259.2	222.7
1/8	104.06	861.79	87.90	275.3	261.1	224.4
1/4	104.45	868.31	88.57	277.4	263.1	226.1
3/8	104.85	874.85	89.23	279.5	265.	227.8
1/2	105.24	881.41	89.96	281.6	267.1	229.5
5/8	105.63	888.	90.58	283.7	269.1	231.2
3/4	106.02	894.62	91.25	285.8	271.1	233.
7/8	106.42	901.26	91.93	288.	273.1	234.7

Diam.	Circum.	Area	Aluminum	Bronze	Brass	Cast Iron
34.	106.81	907.92	92.61	290.1	275.1	236.4
1/8	107.20	914.61	93.29	292.2	277.1	238.2
1/4	107.60	921.32	93.97	294.4	279.2	240.
3/8	107.99	928.06	94.66	296.5	281.2	241.7
1/2	108.38	935.82	95.45	299.	283.6	243.7
5/8	108.77	941.61	96.04	300.8	285.3	245.2
3/4	109.17	948.42	96.71	302.9	287.3	246.9
7/8	109.56	955.25	97.44	305.2	289.4	248.7
35.	109.95	962.11	98.14	307.4	291.5	250.5
1/8	110.34	969.00	98.84	310.	293.6	252.3
1/4	110.74	975.91	99.54	311.8	295.7	254.1
3/8	111.13	982.84	100.2	314.	297.8	255.9
1/2	111.52	989.80	100.9	316.2	300.	257.7
5/8	111.91	996.78	101.6	318.5	302.	259.6
3/4	112.31	1003.8	102.4	320.7	304.2	261.4
7/8	112.70	1010.8	103.1	323.	306.3	263.2
36.	113.09	1017.9	103.8	325.2	308.4	265.1

To find the weight of hexagon section multiply the weight given for round section of same diameter by 1.12. If octagon multiply by 1.082.

Table Giving Circumference, Area and Weight of Round Plates 1 Inch Thick From 3 to 12 Feet Diam.

Diam.	Circumference	Area of Circle	Weight	Diam.	Circumference	Area of Circle	Weight
37″	116.23	1075.21	280	71″	223.05	3959.2	1032
38	119.38	1134.11	296	72	226.19	4071.51	1061
39	122.52	1194.59	311	73	229.33	4185.4	1091
40	225.66	1256.64	327	74	232.47	4300.85	1122
41	128.80	1320.25	344	75	235.62	4417.87	1153
42	131.94	1385.45	361	76	238.76	4536.47	1183
43	135.08	1452.2	379	77	241.90	4656.64	11214
44	138.23	1520.53	396	78	242.04	4778.37	1246
45	141.37	1590.43	415	79	248.18	4901.68	1278
46	144.51	1661.91	434	80	251.32	5026.56	1310
47	147.65	1734.95	453	81	254.46	5153.01	1343
48	150.79	1809.56	472	82	257.61	5281.03	1377
49	153.93	1885.75	491	83	260.75	5410.62	1410
50	157.08	1963.5	512	84	263.89	5541.78	1445
51	160.22	2042.83	533	85	267.03	5674.51	1479
52	163.36	2123.72	553	86	270.17	5808.82	1515
53	166.50	2206.19	575	87	273.31	5944.69	1550
54	169.64	2290.23	597	88	276.46	6082.14	1586
55	172.78	2375.83	620	89	279.60	6221.15	1622
56	175.92	2463.01	642	90	282.74	6367.74	1658
57	179.07	2551.76	665	91	285.88	6503.90	1696
58	182.21	2642.09	689	92	289.02	6647.63	1733
59	185.35	2733.98	713	93	292.16	6792.92	1772
60	188.49	2827.44	737	94	295.31	6939.79	1809
61	191.63	2922.47	762	95	298.45	7088.24	1848
62	194.77	3019.08	787	96	301.59	7238.25	1887
63	197.92	3117.25	813	97	304.7	7389.83	1927
64	201.06	3217.65	838	98	307.8	7542.98	1967
65	204.20	3318.31	865	99	311.01	7697.71	2007
66	207.34	3421.2	892	100	314.16	7854.00	2048
67	210.48	3525.66	919	9 ft.	339.29	9160.88	2382
68	213.62	3631.69	945	10 “	376.99	11309.73	2941
69	216.77	3739.29	975	11 “	414.69	13684.78	3558
70	219.91	3848.46	1003	12 “	452.39	16286.02	4234

CUTTING PRICES

(With Apologies to "Hamlet.")

To cut or not to cut. That is the question.
Whether it is not better in the end
To let the chap who knows not the worth
Have the business at cut-throat prices, or
To take up arms against his competition,
And by opposing cut for cut, end it.
To cut—and by cutting put the other cutter
Out of business—'tis a consummation
Devoutly to be wished. To cut—to slash—
Perchance myself to get it in the neck—
Aye—there's the rub; for when one starts to meet
The other fellow's prices, 'tis like as not
He's up against it good and hard.
To cut and to slash is not to end the confusion
And the many evils the trade is pestered with;
Nay, nay, Pauline; 'tis but the forerunner
Of debt and mortgage such a course portends.
'Tis well to get the price the goods are worth
And not be bluffed into selling them for what
So-and-so will sell his goods for.
Price-cutting doth appear unseemly
And fit only for the man who knows not
What his goods are worth, and who, ere long,
By stress of making vain comparison
'Twixt bank account and liabilities,
Will make his exit from the business.

Anon.

DISTANCES BETWEEN AMERICAN CITIES

FROM	New York	Chicago	Philadelphia	St. Louis	Boston	Baltimore	Cleveland	Buffalo	San Francisco	Pittsburg	Cincinnati	Milwaukee	New Orleans	Washington	Minneapolis
To	Mls.	Mls.	Mls.	Mls.	Mls.	Mls.	Mls.	Mls.	Mls.	Mls.	Mls.	Mls.	Mls.	Mls.	Mls.
Albany	145	832	236	1,028	202	333	480	297	3,106	567	724	917	1,517	373	1,252
Atlanta	876	733	785	611	1,106	688	736	919	2,805	805	492	818	496	648	1,153
Baltimore	188	802	97	934	418	.....	174	398	3,076	334	593	887	1,181	40	1,222
Boston	217	1,034	321	1,230	.....	418	682	499	3,308	674	926	1,119	1,602	458	1,454
Buffalo	442	525	416	731	499	398	183	.....	2,799	270	427	610	1,256	438	945
Chicago	912	.....	821	284	1,034	802	357	525	2,274	468	298	85	912	790	420
Cincinnati	757	298	666	341	926	593	244	427	2,572	313	.....	383	829	553	718
Cleveland	584	357	493	548	682	474	.....	183	2,631	135	244	442	1,073	437	777
Columbus, O.	637	314	546	428	820	511	138	321	2,588	193	116	399	935	471	734
Denver	1,934	1,022	1,843	916	2,056	1,850	1,379	1,537	1,371	1,490	1,257	1,107	1,347	1,810	884
Detroit	693	272	669	488	750	649	173	251	2,546	321	263	357	1,092	655	692
Duluth	1,391	479	1,300	728	1,513	1,281	701	1,004	2,238	947	777	422	1,447	1,269	162
El Paso	2,310	1,465	2,219	1,245	2,414	2,179	1,703	1,915	1,287	1,866	1,586	1,550	1,195	2,139	1,521
Galveston	1,792	1,144	1,691	860	2,012	1,594	1,408	1,591	2,157	1,481	1,157	1,229	410	1,554	1,340
Gr. Rapids, Mich.	821	178	815	462	878	796	332	379	2,452	462	308	263	1,090	764	598
Helena	2,452	1,540	2,361	1,549	2,574	2,342	1,897	2,065	1,250	2,008	1,838	1,455	2,152	2,320	1,119
Indianapolis	825	183	734	240	965	704	283	466	2,457	381	111	268	888	664	603
Jacksonville, Fla.	983	1,097	892	975	1,213	795	1,085	1,193	3,098	1,057	811	1,182	616	755	1,517
Kansas City	1,342	458	1,251	277	1,466	1,211	755	967	1,981	898	618	543	880	1,171	573
Los Angeles	3,149	2,265	3,058	2,084	3,273	3,018	2,562	2,774	475	2,705	2,425	2,350	2,007	2,978	2,301
Louisville	871	304	780	274	1,040	703	358	541	2,468	427	114	389	778	663	727
Memphis	1,157	527	1,066	311	1,387	969	738	921	2,439	807	494	612	396	929	897

Milwaukee	997	85	906	369	1,119	887	442	610	2,359	553	383	.....	997	875	335
Minneapolis	1,332	420	1,241	586	1,454	1,222	777	945	2,096	888	718	335	1,285	1,210	.....
Mobile	1,231	929	1,140	647	1,461	1,043	1,029	1,212	2,623	1,098	785	1,014	141	1,003	1,233
Montreal	386	841	477	1,051	330	574	623	434	3,115	704	826	926	1,655	614	1,125
Newark, N. J.	9	903	82	1,056	226	179	575	405	3,177	435	748	988	1,363	219	1,323
New Haven	76	980	167	1,141	140	264	628	445	3,254	520	833	1,065	1,448	304	1,400
New Orleans	1,372	912	1,281	699	1,602	1,184	1,073	1,256	2,482	1,142	829	997	.....	1,144	1,285
New York	.....	912	91	1,065	217	188	584	442	3,186	444	757	997	1,372	228	1,332
Ogden	2,496	1,494	2,315	1,414	2,528	2,296	1,851	2,019	780	1,962	1,792	1,579	1,891	2,284	1,316
Omaha	1,405	493	1,314	413	1,527	1,295	1,750	1,018	1,781	961	791	578	1,080	1,283	381
Philadelphia	91	821	.....	974	321	97	493	416	3,095	353	666	906	1,281	137	1,241
Pittsburg	444	468	353	621	674	334	135	270	2,742	.....	313	553	1,142	302	888
Portland, Me.	332	1,149	436	1,345	115	533	797	614	3,423	789	1,041	1,234	1,717	573	1,569
Portland, Ore.	3,204	2,292	3,113	2,212	3,326	3,094	2,649	2,817	772	2,760	2,590	2,378	2,746	3,082	2,042
Providence	190	1,034	281	1,230	45	378	682	499	3,308	634	926	1,119	1,562	418	1,454
Quebec	530	1,013	621	1,343	402	718	795	612	3,287	876	1,039	1,098	1,827	786	1,433
Richmond, Va.	343	879	252	918	573	155	553	553	3,153	417	581	964	1,046	115	1,299
Rochester, N. Y.	373	603	361	799	430	354	251	68	2,877	338	495	688	1,324	394	1,023
St. Joseph, Mo.	1,392	470	1,301	327	1,474	1,261	875	1,058	1,867	948	668	555	941	1,221	485
St. Louis	1,065	284	974	.....	1,230	934	548	731	2,194	621	341	369	699	894	586
St. Paul	1,322	410	1,231	576	1,444	1,212	767	935	2,086	878	708	325	1,275	1,200	10
San Antonio	1,943	1,204	1,852	920	2,150	1,755	1,468	1,651	1,911	1,541	1,217	1,289	571	1,715	1,320
San Francisco	3,186	2,274	3,095	2,194	3,308	3,076	2,631	2,799	.....	2,742	2,572	2,359	2,482	3,064	2,096
Seattle	3,151	2,239	3,060	2,332	3,273	2,941	2,596	2,764	957	2,707	2,537	2,154	2,931	3,029	1,818
Spokane	2,812	1,900	2,721	1,932	2,934	2,702	2,257	2,425	1,205	2,368	2,198	1,815	2,535	2,690	1,479
Springfield, Mass.	139	935	230	1,131	99	327	583	400	3,209	583	827	1,020	1,511	367	1,355
Tampa, Fla.	1,195	1,309	1,104	1,187	1,425	1,007	1,297	1,405	3,310	1,269	1,053	1,394	828	967	1,729
Toledo	705	244	615	437	795	595	113	296	2,518	261	203	329	1,032	595	664
Washington	228	790	137	894	458	40	437	438	3,064	302	553	875	1,144	.....	1,210

By the shortest usually traveled railroad routes. Compiled from the War Department's official table of distances.

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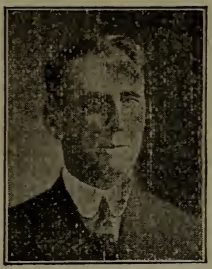

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